Name______________ Student ID___________________ Department/Year__________

Midterm Examination

Introduction to Computer Networks
Class#: 901 E31110
Fall 2012

9:30-11:10 Thursday
November 8, 2012

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), 5 questions.
2. Write your **name in Chinese**, student ID, and department/year down on top of the first page.
3. There are in total 100 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. Assorted multiple choice questions. Select all choices that apply.

   I. (a)(b)(d) Which of the following access networks provide shared access? (5%)
      (a) WiFi
      (b) Ethernet
      (c) ADSL modem
      (d) Cable Modem

   II. (b)(c)(d) Which of the following pair of properties do not contrast a circuit-switched vs. packet-switched network? (5%)
      (a) Dedicated vs. shared
      (b) Store and forward vs. call setup
      (c) Flexible vs. idle
      (d) contention vs. packet re-ordering

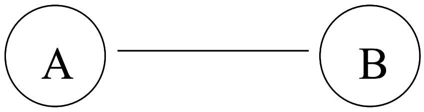
   III. (a)(b) What of the following may be the result of using a Web proxy? (5%)
      (a) Shortened delay
      (b) Lowered uplink bandwidth requirement at the server
      (c) Fresher webpage
      (d) Higher downlink bandwidth requirement at the client

   IV. (c)(d) Which of the following is true about HTTP, FTP and SMTP? (5%)
      (a) HTTP is a push-based protocol.
      (b) SMTP is a pull-based protocol.
      (c) HTTP sends control messages in band.
      (d) FTP sends control messages out of band.

   V. (b)(c) What functionalities do TCP and UDP have in common? (5%)
      (a) Reliable transfer
      (b) Checksum
      (c) Multiplexing
      (d) Connection establishment

   VI. (a)(b)(d) Which of the following is true about TCP's reliable data transfer? (5%)
      (a) TCP may retransmit packets upon receiving duplicate acknowledgements.
      (b) TCP may retransmit packets upon timer timeout events.
      (c) TCP receiver always transmits acknowledgement immediately upon receiving a data packet.
      (d) TCP uses cumulative acknowledgement.

2. (Overview) Consider a simple network as follows. The bandwidth of the link is R bits per second and the packets always come in the size of P bytes. The link speed is S meter per second and the length of the link is D meters.



(1) Give the transmission delay of a packet (in terms of R, P, S, or D). (5%)
(2) Give the propagation delay of the link (in terms of R, P, S, or D). (5%)
(3) Suppose node A has infinite amount of buffer space and the data (from the application layer) of node Aare to be forwarded to node B in a constant rate, 2R. Give the amount of data waiting to be transmitted in node A at time T seconds (in terms of T, R, P, S, or D). (5%)
(4) Continue from (3). Suppose the processing delay is negligible. Give the nodal delay of the packet arriving at node A at time T (in terms of T, R, P, S, or D). (5%)

Sample Solution:

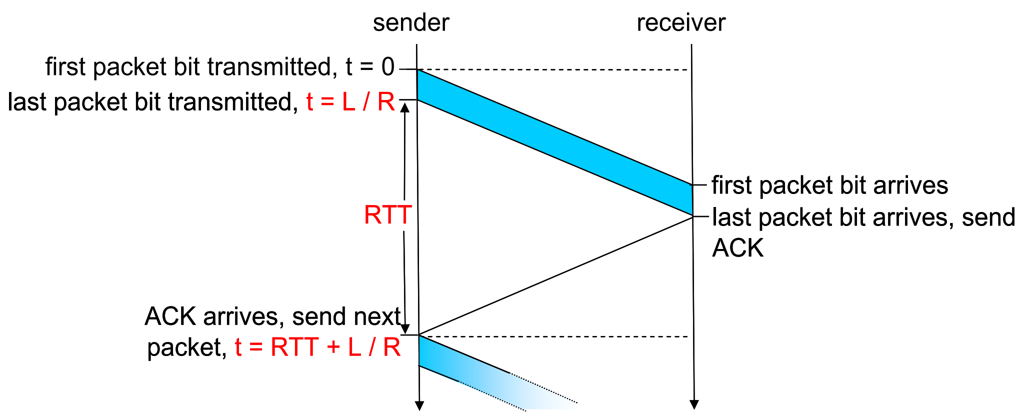
(1) 8P/R seconds
(2) D/S seconds
(3) RT bits
(4) T + 8P/R + D/S seconds

3. (Application) Consider a circular DHT-based peer-to-peer file system. In that, the files are numbered. The file ID ranges from 0 to 127. The circular DHT has at most 8 nodes, where the node ID ranges from 0 to 7. The key space is identical to the node ID space, thus ranging also from 0 to 7. The hash function is defined as simple as: key = file ID mod 8. When all nodes of the circular DHT are up running, a file is stored in the node whose ID = key. Otherwise, the file is stored in the immediate successor of the node with ID = key.
   (1) If all 8 nodes of the circular DHT are online, how many files are stored in each node? (5%)
   (2) If nodes with ID=1, 3, 5, 7 are offline, how many files are stored in node 0, 2, 4, and 6? (5%)
   (3) If nodes with ID=1, 2, 3, 4 are offline, how many files are stored in node 0, 5, 6, and 7? (5%)
   (4) Assume the system knows which nodes in the circular DHT are onlines and how many files each of the nodes store. Can you devise a better hash function or scheme such that the number of files stored in the online nodes in scenario (2) and (3) will be more balanced than the simple "file ID mod 8"? (5%)

Sample Solution:
   (1) 16, 16, 16, 16, 16, 16, 16, 16
   (2) 32, 32, 23, 32
   (3) 16, 80, 16, 16
   (4) Any solution that works better

4. (Transport) Consider rdt 3.0. To ensure reliable transfer, the sender sends a packet and waits for the acknowledgement to come back in one round. Assume there is no error. The total time to complete reliable transfer of a packet is $L/R+RTT$, where L is the packet size in bits, R is the link rate in bits per second, RTT is the round-trip time between the sender and receiver in seconds. During the $L/R+RTT$ seconds of time, the fraction used really to transmit data is L/R. Therefore, the system utilization of rdt 3.0 is

$$\frac{L/R}{RTT + L/R}.$$



Consider rdt3.0 with pipelining, where N packets are sent back to back within a round. Note that $N * L/R$ is significantly smaller than RTT. Derive the following terms step by step to come to the utilization of rdt3.0 with N pipelined packets for long data transfers.

(1) The total time to complete reliable transfer of these N back to back packets (5%)
(2) The utilization of rdt 3.0 with N pipelined packets in one round (5%)
(3) The utilization of rdt 3.0 with N pipelined packets in K rounds (5%)
(4) The utilization of rdt 3.0 with N pipelined packets in K rounds when $K \to \infty$ (5%)

Sample Solution:

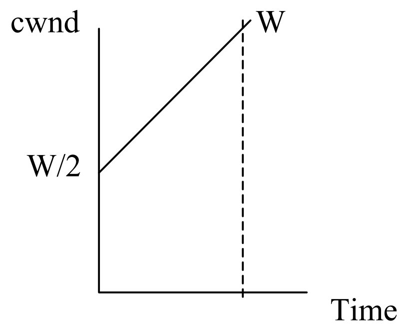
(1) $N * L/R + RTT$

(2) $$\frac{N * L/R}{L/R + RTT + (N-1) * L/R}$$

(3) $$\frac{K * N * L/R}{K * (L/R + RTT) + (N-1) * L/R}$$

(4) $$\frac{N * L/R}{L/R + RTT}$$

5. (Transport) Suppose you work for an Internet radio channel. The company is used to transferring audio by UDP until its ISP starts to notice the large amount of bandwidth this Internet radio company is consuming. The ISP warns the Internet radio company. If the company will not send traffic just like everyone else surfing the WWW, the ISP will stop providing the Internet access service. As the Internet technician of the radio channel, you are asked to provide a solution – a transport layer service that does not guarantee reliability but does TCP friendly congestion control.



Assume the audio transfers are long and it will be sufficient for these transfers to be friendly to TCP in the congestion avoidance state (the steady state). Assume also there exist on the Internet only packet drops due to duplicate acknowledgements. The Figure above depicts the congestion window size (in number of packets) within an average episode of additive increase in the steady state. Try if you can derive the average TCP throughput: MSS/RTT * $(3/2p)^{1/2}$, where MSS is the packet size in bytes, RTT is the round-trip time, and p is the packet drop rate. (10%)

Sample Solution:

It is assumed that there's only dup-ack drop. The cwnd increases always linearly. Therefore, the average TCP throughput is half of the min and max of the average episode:

TCP throughput = (W/2*RTT+W/RTT)*MSS/2 = 3/4 W*MSS/RTT ---- (1)

p is the packet drop rate. That is saying there're 1/p packets sent in between two packet drops. 1/p is therefore total number of packets sent in an average episode:

1/p = (W/2+W) * W/2 /2 = 3/8 W^2

W = $(8/3p)^{1/2}$ ---- (2)

Substitute W in (1) with (2). We get:

TCP throughput = $(3/2p)^{1/2}$ *MSS/RTT