Name_______________ Student ID____________________ Department/Year___________

Final Examination

Introduction to Computer Networks
Class#: 901 E31110
Fall 2012

9:30-11:10 Thursday
January 10, 2013

Prohibited

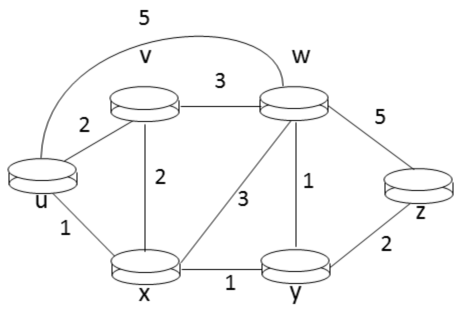
1. You are not allowed to write down the answers using pencils. Use only black- or blue-inked pens.
2. You are not allowed to read books or any references not on the question sheets.
3. You are not allowed to use calculators or electronic devices in any form.
4. You are not allowed to use extra sheets 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), 4 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.

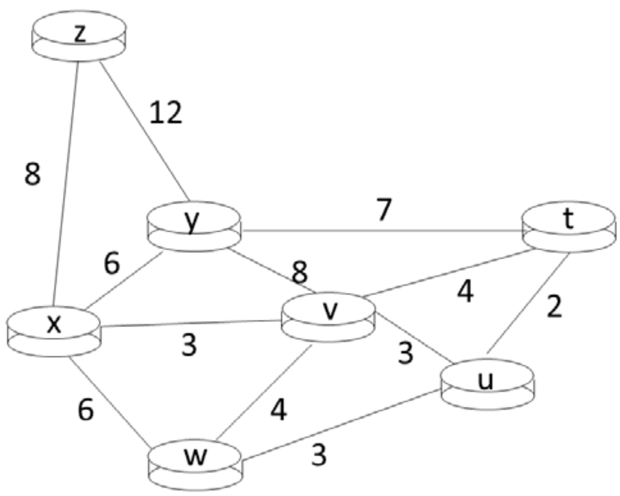
1. Assorted multiple choice questions. Select all choices that apply.
   I. (a)(b)(c) Which of the following IP or subnet address is valid? (5%)
      (a) 224.2.42.1
      (b) 140.112.42.192/28
      (c) 10.1.1.1
      (d) 192.168.1.256
   II. (a)(c) What of the following is a function of the network layer? (5%)
      (a) Routing
      (b) Error recovery
      (c) Forwarding
      (d) IP-to-MAC address translation
   III. (a)(b)(c)(d)Which of the following contrasts LS vs. DV? (5%)
      (a) Global topology information vs. neighbor's knowledge
      (b) LS report broadcast vs. DV local exchange
      (c) Error does not propagate vs. error propagates
      (d) May have route oscillations vs. may have routing loops
   IV. (c) Which of the following is not a property of an ideal multiple access protocol? (5%)
      (a) In a broadcast channel of bandwidth R, when there is only one node sending, it can send at rate R.
      (b) In a broadcast channel of bandwidth R, when there are N nodes sending, each can send at rate R/N.
      (c) Centralized
      (d) Simple
   V. (a)(b)(c)(d) Which of the following is a function of the link layer? (5%)
      (a) Error detection
      (b) Multiple access
      (c) Reliable transmission
      (d) Addressing
   VI. (d) Which of the following is not a characteristic of a wireless link? (5%)
      (a) Interference from other sources
      (b) Decreased signal strength
      (c) Multipath propagation
      (d) Indirect routing

2. (Network layer) Using the Dijkstra shortest-path algorithm, one can compute the shortest path from node u to all network nodes. Given a 6-node network illustrated in the figure below. The table underneath indicates the steps deriving the cost and previous hop on the shortest paths.



Travel Set	D(v),p(v)	D(w),p(w)	D(x),p(x)	D(y),p(y)	D(z),p(z)
u	2,u	5,u	1,u	infinity	infinity
ux	2,u	4,x		2,x	infinity
uxy	2,u	3,y			4,y
uxyv		3,y			4,y
uxyvw					4,y
uxyvwz					

Now, consider the 7-node network illustrated in the figure below. Generate the table indicating the steps deriving the cost and previous hop on the shortest paths from node x to all other network nodes. Note that when the path costs are equal, add nodes to the Travel Set in alphabetic order. (20%)



Sample solution:

Travel Set	D(t),p(t)	D(u),p(u)	D(v),p(v)	D(w),p(w)	D(y),p(y)	D(z),p(z)
x	Infinity	infinity	3,x	6,x	6,x	8,x
xv	7,v	6,v		6,x	6,x	8,x
xvu	7,v			6,x	6,x	8,x
xvuw	7,v				6,x	8,x
xvuwy	7,v					8,x
xvuwyt						8,x
xvuwytz						

3. (Link layer) Ethernet's multiple access protocol CSMA/CD employs an exponential backoff mechanism to determine the random waiting time before each retransmission. The mechanism is to avoid repeated collisions among loaded nodes. To avoid retransmitting indefinite times, there is usually a pre-set maximum on the number of retransmissions allowed. Therefore, when the nodes are over-loaded, there is a slight chance that a node might need to give up and drop a packet – continuing to collide with other nodes after the maximum retransmission attempts. Let us derive the probability of a node dropping a packet (collided at the initial transmission) exhausting the maximal number of retransmissions allowed.
   (1) According to the exponential backoff mechanism, state the range of values the random number K will be chosen from in the n^{th} retransmission. The value of n is no larger than 10. (5%)
   (2) Suppose there are only two nodes sending on to the Ethernet. What is the probability the one node colliding with the other node at the 1^{st} retransmission? What is the probability at the 2^{nd} and 3^{rd} retransmission? (5%)
   (3) Continue from (2). Derive the probability of a node dropping a packet, experiencing an initial collision, after n retransmissions. The value of n is no larger than 10. (5%)
   (4) Consider a 3-node Ethernet. What is the probability of a node colliding with at least one of two other nodes at the 1^{st} retransmission? What is the probability at the 2^{nd} and 3^{rd} retransmission? (5%)
   (5) Continue from (4). Derive the probability of a node dropping a packet experiencing an initial collision after n retransmissions in the 3-node Ethernet. The value of n is no larger than 10. (5%)
   (6) Consider an m-node network. Show that the probability of a node dropping a packet experiencing an initial collision after n retransmissions is $\prod_{i=1}^{n} 1-\left(1-\frac{1}{2^i}\right)^{m-1}$. The value of n is no larger than 10. (5%)

Sample Solution:

(1) K randomly chosen from: {0, 1, 2, 3, …, 2^n-1}

(2) Probability of colliding at 1^{st} retransmission: $\frac{1}{2}$

Probability of colliding at 2^{nd} retransmission: $\frac{1}{4}$

Probability of colliding at 3^{rd} retransmission: $\frac{1}{8}$

(3) Probability of dropping after the n^{th} retransmission: $\frac{1}{2} * \frac{1}{4} * \frac{1}{8} * \ldots * \frac{1}{2^n} = \prod_{i=1}^{n} \frac{1}{2^i}$

(4) Probability of colliding at 1st retransmission: $1-\left(\frac{1}{2}\right)^2$

Probability of colliding at 2nd retransmission: $1-\left(\frac{3}{4}\right)^2$

Probability of colliding at 3rd retransmission: $1-\left(\frac{7}{8}\right)^2$

(5) Probability of dropping after the nth retransmission: $[1-\left(\frac{1}{2}\right)^2]*[1-\left(\frac{3}{4}\right)^2]*[1-\left(\frac{7}{8}\right)^2]*\ldots*[1-\left(\frac{2^n-1}{2^n}\right)^2] = \prod_{i=1}^{n} 1-\left(1-\frac{1}{2^i}\right)^2$

(6) Probability of colliding at 1st retransmission: $1-\left(\frac{1}{2}\right)^{m-1}$

Probability of colliding at 2nd retransmission: $1-\left(\frac{3}{4}\right)^{m-1}$

Probability of colliding at 2nd retransmission: $1-\left(\frac{7}{8}\right)^{m-1}$

Probability of dropping after the nth retransmission: $\prod_{i=1}^{n} 1-\left(1-\frac{1}{2^i}\right)^{m-1}$

4. (Wireless and Mobile) Based on your knowledge of CDMA, address the following questions.
   (1) Suppose Sender #1 is assigned a chip sequence (1, 1, 1, -1, 1, -1, -1, -1). What would be the encoded signal for a bit of data, 1, and what would the encoded signal for -1? (5%)
   (2) Continue from (1). Suppose Sender #2 is assigned another chip sequence (1, -1, 1, 1, 1, -1, 1, 1). If Sender #1 sends a bit, 1, and sender #2 sends a bit, -1, simultaneously, what would be the resulting signal after multiplexing the two encoded signals from the two senders? (5%)
   (3) Continue from (2). Suppose the receiver (knowing the chip sequences of the senders) captures the signals transmitted with no bit errors. Show how the receivers collect the bit sent from Sender #1 and #2 by applying the decoding computation. (5%)
   (4) Continue from (3). As you've studied in freshman Linear Algebra – when two vectors, e.g., X and Y, are orthogonal, X・Y = 0. Consider that Sender #3 joins and sends simultaneously with Sender #1 and #2. Find a chip sequence for Sender #3 such that the CDMA of 3-sender subnet will continue to work. (5%)

Sample Solution:

(1) (1, 1, 1, -1, 1, -1, -1, -1), (-1, -1, -1, 1, -1, 1, 1, 1)
(2) (1, 1, 1, -1, 1, -1, -1, -1) + (-1, 1, -1, -1, -1, 1, -1, -1) = (0, 2, 0, -2, 0, 0, -2, -2)
(3) [(0, 2, 0, -2, 0, 0, -2, -2)・(1, 1, 1, -1, 1, -1, -1, -1)]/8 = 8/8 = 1
    [(0, 2, 0, -2, 0, 0, -2, -2)・(1, -1, 1, 1, 1, -1, 1, 1)]/8 = 8/8 = -1
(4) Any V such that V・(1, 1, 1, -1, 1, -1, -1, -1) = 0 and V・(1, -1, 1, 1, 1, -1, 1, 1) = 0