Name_____ Student ID_____ Department/Year_____

Final Examination

Introduction to Computer Networks
Class#: 901 E31110
Fall 2016

10:20-12:10 Thursday
January 12, 2017

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 16 pages (including this title page), 7 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.

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1. (Transport Layer) There is a pair of nodes transferring data using a pipelined reliable data transfer protocol. I.e., it is either Go-Back-N or Selective Repeat. Suppose the window size is 3. and the timeout interval is substantially longer than the round-trip time + the time to transmit multiple packets.

   To find out exactly which pipelined reliable protocol the connection is using, you install a packet sniffer at the sender side and record the sequence number of data packets coming out of the sender over time. These are what you obtain in 4 data transfers over the node pair:

   Series A: 1, 2, 3, 4, 5, 6, 7, 8, …
   Series B: 1, 2, 3, 1, 2, 3, 4, 5, …
   Series C: 1, 2, 3, 4, 2, 3, 4, 5, …
   Series D: 1, 2, 3, 4, 2, 3, 5, 6, …

   (a) Can you determine if it's GBN or SR the node pair is using seeing only Series A? (2%) Why? (4%)
   (b) Can you determine if it's GBN or SR the node pair is using seeing only Series B? (2%) Why? (4%)
   (c) Can you determine if it's GBN or SR the node pair is using seeing only Series C? (2%) Why? (4%)
   (d) Can you determine if it's GBN or SR the node pair is using seeing only Series D? (2%) Why? (4%)

Sample Solution:

(a) No. Justify your answer. One sample explanation could be - when there's no packet loss, packet will be transmitted out in increasing sequence number using either GBN or SR.

(b) No. Justify your answer. One sample explanation could be – The series can be a result of GBN losing the 1st transmission of packet 1 and of SR losing the 1st transmission of packet 1, 2, and 3. In GBN, losing packet 1 will result in the receiver sending old acks and the sender ignoring the old acks. The timer for packet batch 1-3 will fire and (re)transmit packet 1, 2, and 3 next and subsequently 4 and 5. In the SR case, when the 1st transmission of packet 1, 2, and 3 are all lost, packet 1, 2, 3's timer will run out, (re)transmission of packet 1, 2, 3 will go next. When the acks of packet 1, 2, 3 arrive at the sender, the window will slide to packet 4-6 and send packet 4, 5, 6 next.

(c) No. Justify your answer. One sample explanation could be – The series can be a result of GBN losing the 1st transmission of packet 2 and of SR losing the 1st transmission of packet 2, 3, and 4. In the BGN case, receiver will send ack 1 and the batch 1-3 timer will be removed and the timer for batch 2-4 will be started and packet 4 will be transmitted. Timer for batch 2-4 will eventually fire and packet 2, 3, and 4 are (re)transmitted. In SR's case, ack 1 will trigger packet 4 being sent. Timer for packet 2, 3, and 4 will be fired subsequently. And therefore, packet 2, 3, and 4 (re)transmitted next.

(d) Yes. Justify your answer. One sample explanation could be –
The series can be the result of SR sender when the 1st transmission of packet 2 and 3 are lost, ack 1 will return first to trigger the window sliding over to 2-4 and transmit packet 4 next. Packet 2 and 3's timers will fire next (even though the ack for packet 4 may have returned to the sender). The sender will retransmit packet 2 and 3 next. When the acks for packet 2 and 3 come back, the window will slide over to 5-7 and transmit packet 5, 6, and 7 next.

The series cannot be the result of GBN sender because in GBN every retransmission retransmits a batch. In this case, 3 packets in consecutive sequence numbers. To retransmit packet 2 and 3, the batch 2-4 timer should be fired. And packet 2, 3, and 4 should be retransmitted subsequently, not 2, 3, and 5.

2. (Transport Layer) Recall congestion control in TCP.
   (a) Describe how TCP increases the congestion window size (cwn) in slow start state and in congestion avoidance state. (4%)
   (b) Describe how TCP decreases the congestion window size when a packet loss is detected due to retransmission timeout vs. 3 duplicate acknowledgements. (4%)
   (c) Describe how TCP determines when to switch from the slow start state to the congestion avoidance state. (2%)

Sample Solution:

(a) SS: adding cwn=cwn+1 packet per ack
    CA: adding cwn=cwn+1/cwn packet per ack
(b) Timeout: cwn=1 packet
    3 duplicate ack: cwn=cwn/2
(c) When cwn > ss threshold

3. (Network Layer) One of the main jobs a router is responsible for is forwarding packets. Consider a router containing a forwarding table as follows.

Destination Prefix	Interface
11001000 00010111 0000	1
11001000 00010111 00001	2
11001000 00010111 00000	3
11001000 00010111 10001	4
default	5

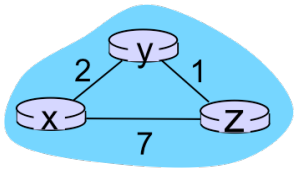
Now 4 packets come along with the following destination addresses. Based on the longest match principle, which interfaces will the 4 packets be forwarded to?

(a) 11001000 00010111 01000000 10110000 (2%)
(b) 11001000 00010111 00000011 10110000 (2%)
(c) 11001000 00010111 00001000 10110000 (2%)
(d) 11001000 00010111 10001000 10110000 (2%)

Sample Solution:

(a) 5
(b) 3
(c) 2
(d) 4

4. (Network Layer) Consider the following network running Distance Vector (DV) routing and address the following questions about 'bad news travel slow'.



(a) Develop the DV table at x, y, z when the DV tables stabilize. (4%)

(b) Suppose the cost on ink x-y suddenly increases to 4. Develop the DV table at node x, y, and z right after the change at t0. Develop the DV table at node x, y, and z at the next iteration t1 and t2. Fill in the blanks in the DV table provided in page 9 and show your derivation/computation. (9%)

(c) Suppose the cost on link x-y suddenly increases to 60. Develop the DV table at node x, y, and z right after the change t0. Develop the DV table at node x, y, and z at the next iteration t1 and t2. Fill in the blanks in the DV table provided in page 10 and show your derivation/computation. (9%)

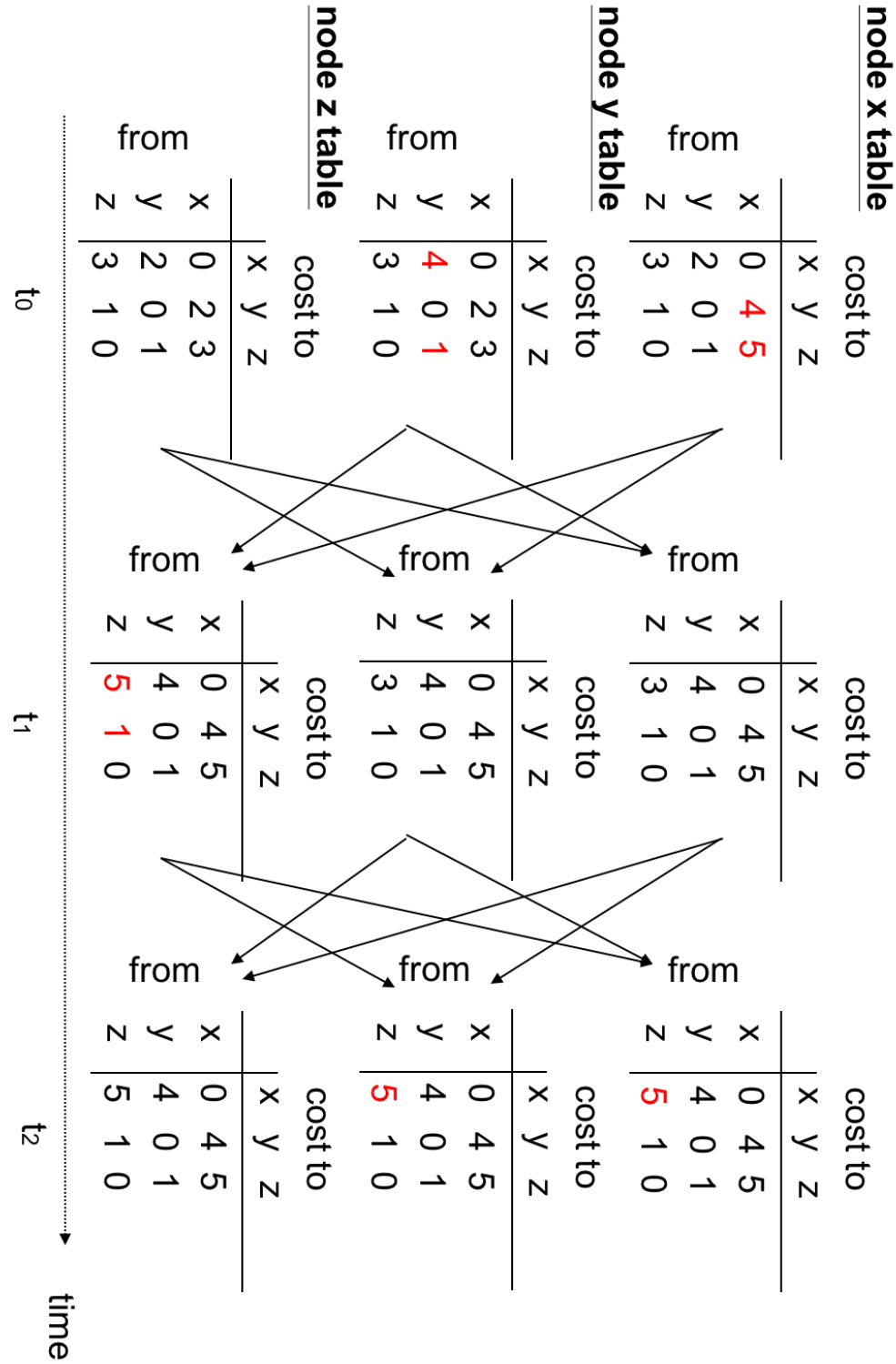
(d) Changing the link cost from 2 to 4, and from 2 to 60 are both bad news. Do you find one bad news travel slower than another (2%) and why? (4%)

Sample Solution:

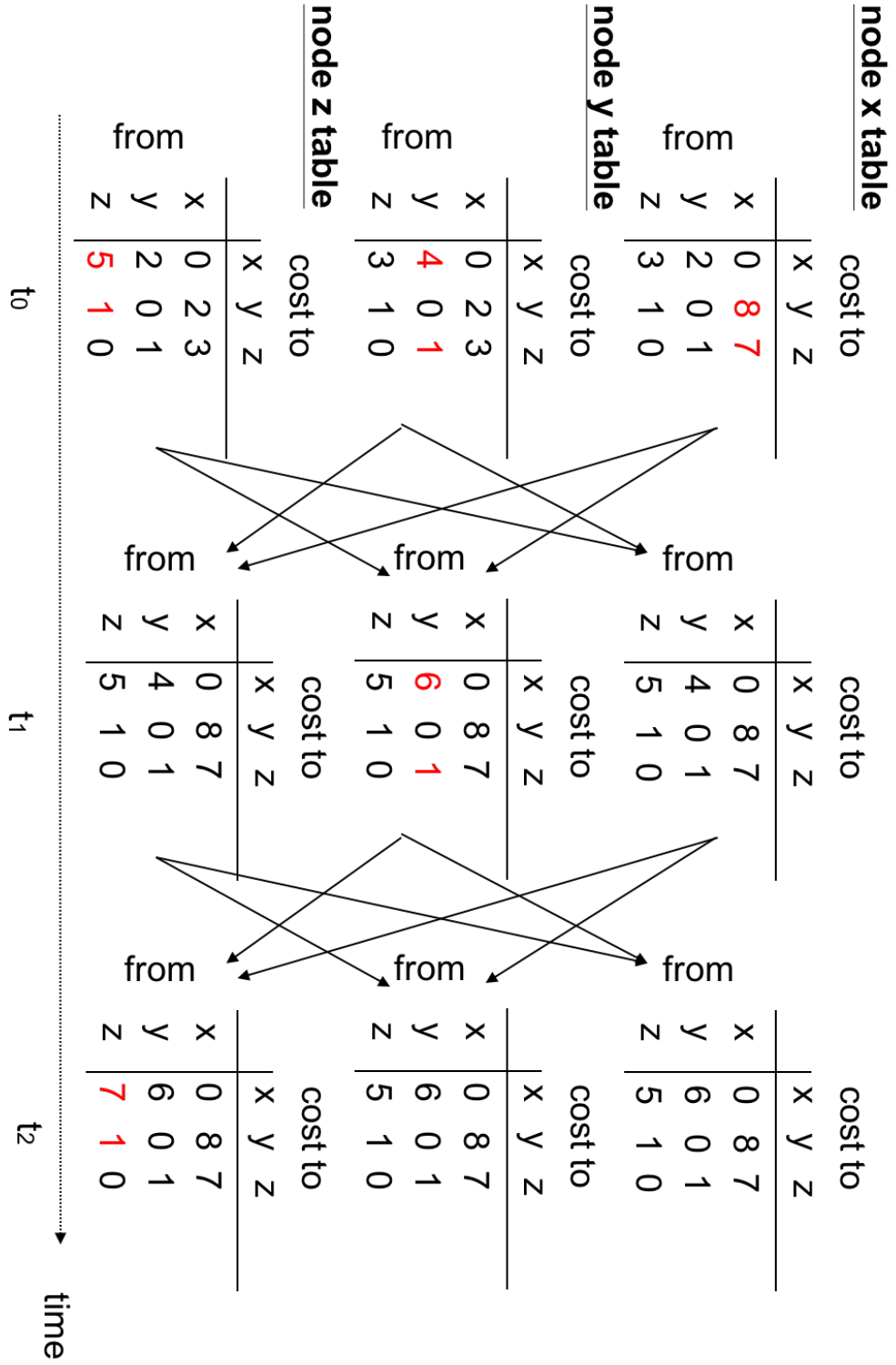
(a)

		cost to		
		x	y	z
from	x	0	2	3
	y	2	0	1
	z	3	1	0

(b)

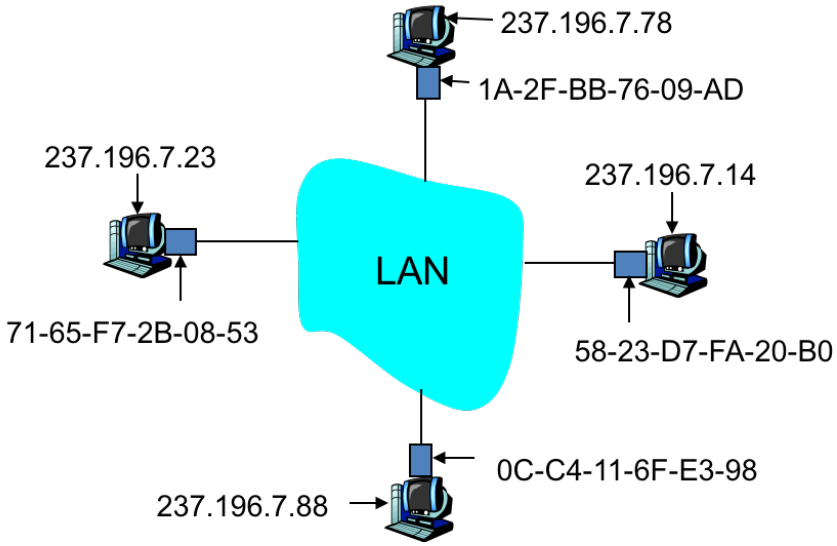

node x table
node y table
node z table
cost to
from
x y z
time
t0
t1
t2

(c)


node x table
node y table
node z table
cost to
from
x y z
time
t0
t1
t2

(d) Yes. The case of changing the link cost to 60 converges slower. So it seems that bigger ‘bad news’ travel slower. Because it might take more iterations for the effect of the ‘good link’ to be flashed out.

5. (Link Layer) Consider an Ethernet subnet just started up. I.e., The ARP table on all network interfaces are empty. Suppose the node with IP address 237.196.7.23 suddenly wants to send a data packet to the node 237.196.7.14.



(a) What is the destination address of the 1st Ethernet frame out on the subnet? (2%)

(b) What is the destination address of the 2nd Ethernet frame out on the subnet? (2%)

(c) What is the destination address of the 3rd Ethernet frame out on the subnet? (2%)

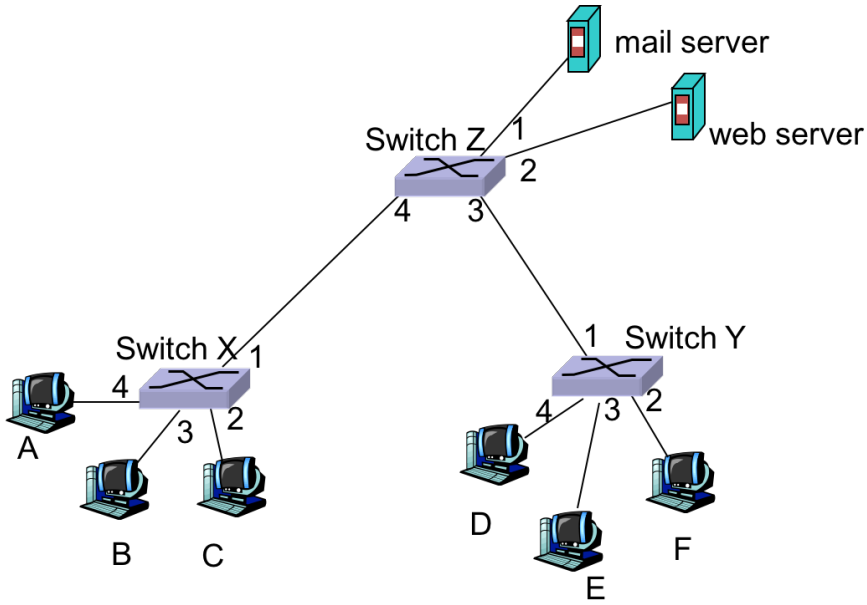
Sample Solution:

(a) FF-FF-FF-FF-FF-FF

(b) 71-65-F7-2B-08-53

(c) 58-23-D7-FA-20-B0

6. (Link Layer) Consider the following institutional network connected by 3 link-layer switches, namely X, Y, and Z. Update the switch table on each of the switches after the following operations.



(a) After A sends a Web request to the Web server (4%)
(b) After the Web server replies to A (4%)
(c) After E sends a Web request to the Web server (4%)
(d) After the Web server replies to E (4%)

Sample Solution:

	Switch X		Switch Y		Switch Z	
	dest	inf	dest	inf	dest	inf
(a)	A	4	A	1	A	4
(b)	WS	1			WS	2
(c)			E	3	E	3
(d)			WS	1		

7. (Wireless) We have come across three categories of MAC protocols: (1) partitioning, (2) random access, and (3) taking turn. Classify the following MAC protocols into the categories and justify your choices.

   (a) Ethernet (2%)
   (b) WiFi (2%)
   (c) Bluetooth (2%)
   (d) 2G (2%)

Sample Solution:

Your choices and justification, as long as it makes sense. Here's one possibility.

(a) Ethernet: random access, as it employs CSMA/CD a random access MAC that does not partition the bandwidth or take strict turns among the nodes on the subnet.
(b) WiFi: random access, as it employs CSMA/CA a random access MAC that does not partition the link bandwidth a priori or take strict turns among the nodes on t he subnet
(c) Bluetooth: taking turn. The master node polls the slaves. The slaves wishing to send data will request when being polled and the master will grant access before the slaves get to transmit data.
(d) 2G: partitioning, as it employs a FDMA+TDMA MAC that partition bandwidth into pieces and assign to particular nodes a priori.