Concordia University
Department of Computer Science & Software Engineering
Instructor: Dr. Ebrahim Soujeri
Time: 3 hours
Date: Thursday, December 6, 2012 **Final Examination**

COMP 445, Fall 2012

Name: ____________________

I.D.#: ____________________

For instructor use only. Do NOT write anything inside this table.

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12

Attempt all questions. Total marks of the exam are: 100 marks.

All questions must be answered in this examination booklet.

This examination booklet consists of **13** pages. You must check that you have 13 pages before starting the exam.
ENCS Calculators are allowed. Exam is closed book.

Here are some general formulas that you may find useful:

$$d_{trans} = L / R$$

$$U_{sender} = \frac{d_{trans}}{d_{trans} + d_{prop}}$$

$$D_{cs} = \max\left\{\frac{NF}{u_s}, \frac{F}{d_{\min}}\right\}$$

$$D_{P2P} = \max\left\{\frac{F}{u_s}, \frac{F}{d_{\min}}, \frac{NF}{u_s + \sum_{i=1}^{N} u_i}\right\}$$

Given v: speed, x: distance, t: time
$v = x / t$

Speed of light: $3\times10^8\ m/\sec$

For m collisions, $k = 0,\ldots,2^m$, Next shooting times: $512 \times k \times$ bit time (seconds).

Question # 1 (marks)

Suppose two hosts *A* and *B* are separated by 20,000 kilometers and are connected by a link of 2Mbps. Given a propagation speed of $2.5\times10^{8}\ m/\sec$.

a) Find the bandwidth-delay product $R\cdot d_{prop}$.

$$d_{prop}=\frac{20\times10^{6}m}{2.5\times10^{8}\ m/\sec}=\frac{20}{250}=0.08\sec \quad \Rightarrow \quad R\cdot d_{prop}=2\times10^{6}\times0.08=160,000\ bits$$

b) If *A* sends a file of size 800,000 bits to *B* as one large message, what is the maximum number of bits that will be in the link at any given time?

➔ $160,000\ bits$

c) What is the width (in meters) of a bit in the link?

The time needed to transmit 1 bit is 1/2Mbps = 0.5 micro seconds
In 0.5 micro seconds, the packet has propagated a distance of

$$x=v.t=\left(0.5\times10^{-6}\sec\right)\cdot\left(2.5\times10^{8}m/\sec\right)=125\ meters$$

Question # 2 (marks)

Consider distributing a file of size 20 Gbits to 31 peers. The server has an upload rate of 3 Mbps and each peer has a download rate of 2 Mbps and an upload rate of 1Mbps.

A) Find the minimum distribution time for both client-server and peer-to-peer distributions.

For the client-server case:

$$\frac{NF}{u_s}=\frac{31\times20\times10^{9}}{3\times10^{6}}=206666.67\sec \qquad \frac{F}{d_{\min}}=\frac{20\times10^{9}}{2\times10^{6}}=10000\sec$$

$$D_{cs}=\max\left\{\frac{NF}{u_s},\frac{F}{d_{\min}}\right\}=206666.67\sec$$

For the peer-to-peer case:

$$\frac{F}{u_s}=\frac{20\times10^{9}}{3\times10^{6}}=6666.67\sec \qquad \frac{F}{d_{\min}}=\frac{20\times10^{9}}{2\times10^{6}}=10000\sec$$

$$\frac{NF}{u_s+\sum_{i=1}^{N}u_i}=\frac{31\times20\times10^{9}}{3\times10^{6}+31\times10^{6}}=18235.3\sec$$

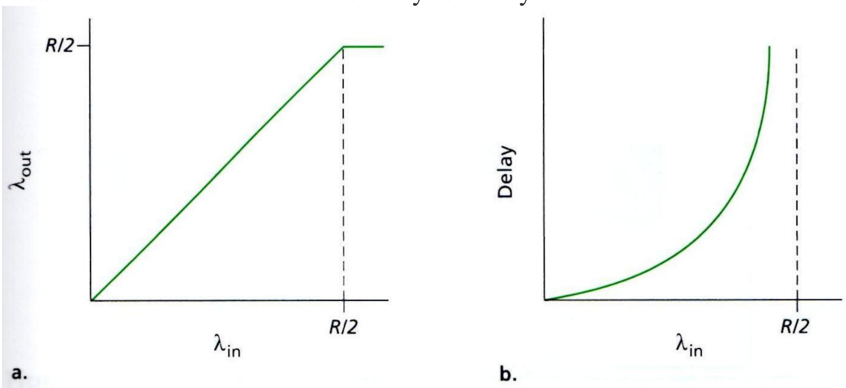
$$D_{P2P}=\max\left\{\frac{F}{u_s},\frac{F}{d_{\min}},\frac{NF}{u_s+\sum_{i=1}^{N}u_i}\right\}=18235.3\sec$$

B) Which architecture is faster? Explain the reasons very clearly.

It is very clear that the peer-to-peer architecture is more than 11 times faster.

Question # 3 (marks)

Consider the curves shown below. What exactly these curves describe? How do you interpret them? Please answer in one or two lines only for every curve.



Two hosts A and B each have a connection that shares a single hop between source and destination.
Host A sends data to into the connection at an average rate of λ_{in} bytes / second.
Data are original – each unit is sent into network only once (no duplicates).
Data are encapsulated and sent; no error recovery, flow control or congestion control is employed.
B sends to A in a similar scenario

A and B exchange packets over a shared router of capacity R.
The router has *infinite buffer space* to store incoming packet when arrival rate exceeds departure rate.

Answer for Curve (a)

Per-connection throughput as a function of the connection-sending rate.

For a transmission rate between 0 and R/2:
Transmission equals reception rate.

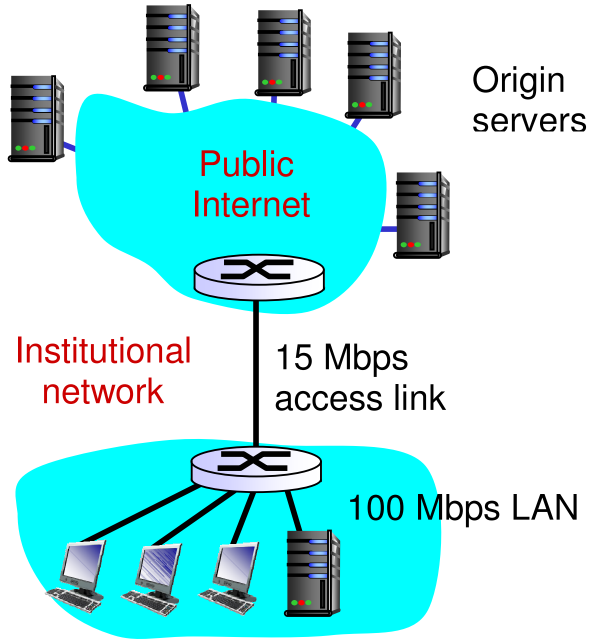
For a transmission rate above R/2:
Throughput is limited to R/2. Limitation is a consequence of sharing.
Neither A nor B will never achieve a throughput higher than R/2.

Answer for Curve (b)

Being near full capacity is good, however,
the consequence of operation near FULL link capacity causes extreme delays (infinite).

Question # 4 (marks)

An institutional high speed LAN is connected to the global internet by a 15Mbps link as shown. The average object size in the institutional network is 1Mbits and the average number of overall requests within the LAN is 15 requests per second.



Assuming an internet RTT delay of 2 sec and an overall within LAN delay of 0.01 sec.

a) What is the traffic intensity on the LAN?

Traffic intensity on the LAN is:

$15/100 = 0.15$

b) What is the traffic intensity on the access link?

$15/15 = 1$

c) Is it possible to calculate an exact value for the delay? If *yes*, explain how this can be achieved. If *no*, explain the reasons behind this incapability. Hint: Question 3(b) might help.

It is not possible to find the delay exactly, but it will be a very long delay, as described in 3(b).

Question # 5 (marks)

Consider the problem given in Question # 4.

A) Which one of the following solutions is a better solution to solve the delay problem: Adding an institutional cache server or upgrading the access link? Explain clearly why this solution is better.

Upgrading the access link will be very costy. Adding an institutional cache is much better and cheaper.

B) If the access link is upgraded to 60 Mbps, what will be the traffic intensity on the access link?

$15/60 = 0.25$

C) If an institutional cache server is added; if 45% of the requests (clicks) are local. Find the average delay.

Given that LAN delay: 0.01 and internet delay (RTT): 2

Average delay would be:

$0.45 \times 0.01 + 0.55 \times 2.01 = 1.11$ seconds

Question # 6 (marks)

Code-division multiple-access (CDMA) is superior to TDMA and FDMA because it does not have time or frequency restrictions. CDMA is the core technology for GPS, 3G and 4G systems. Given a basic CDMA system with K=5 users and L=8 chips per bit.

a) What is the maximum number of users this system can handle?

8 users

b) Suppose an incoming noisy CDMA signal at the receiver (over a period of 1 bit) to be:

-0.69 0.86 -2.75 -5.59 -1.44 0.57 -4.40 4.69

Extract this single bit for the five users whose *spreading sequences* (*signature waveforms*) are given as:

User1:	1	-1	1	-1	1	-1	1	-1
User2:	1	1	-1	-1	1	1	-1	-1
User3:	1	-1	-1	1	1	-1	-1	1
User4:	1	1	1	1	-1	-1	-1	-1
User5:	1	-1	1	-1	-1	1	-1	1

Use a hard-limiter to decide on the output bits.

For all 5 users, let k=1,2,..,5 and

$$r_k = \langle c_k \cdot r \rangle$$

$$\hat{d}_k = sign(r_k)$$

Here,

$$r_1 = \langle c_1 \cdot r \rangle = -9.81 \qquad r_2 = \langle c_2 \cdot r \rangle = +7.35 \qquad r_3 = \langle c_3 \cdot r \rangle = +2.69$$

$$\hat{d}_1 = sign(r_1) = -1 \qquad \hat{d}_2 = sign(r_2) = +1 \qquad \hat{d}_3 = sign(r_3) = +1$$

$$r_4 = \langle c_4 \cdot r \rangle = -7.59 \qquad r_5 = \langle c_5 \cdot r \rangle = +12.39$$

$$\hat{d}_4 = sign(r_4) = -1 \qquad \hat{d}_5 = sign(r_5) = +1$$

Note:

Sign(x) = 1 if x>0

Sign(x) = -1 if x<0

c) In CDMA, cross-correlation matrix R is defined to be the matrix resulting from multiplying the signature waveform matrix by its transpose. Find R. Hint: R is a $K \times K$ matrix.

$$R = \begin{bmatrix} 8 & 0 & 0 & 0 & 0 \\ 0 & 8 & 0 & 0 & 0 \\ 0 & 0 & 8 & 0 & 0 \\ 0 & 0 & 0 & 8 & 0 \\ 0 & 0 & 0 & 0 & 8 \end{bmatrix}$$

Question # 7 (marks)

Given a generator vector $G = 10011$. Use either long division method or binary division to find the cyclic redundancy code CRC for the data sequence $d = 1\ 1\ 0\ 0\ 1\ 1\ 0\ 1\ 0\ 1$.

Hint: Pad the data sequence with the necessary number of zero bits before dividing.

					⇩												
					1	1	0	1	1	0	1	1	1	0			
1 0 0 1 1	1	1	0	0	1	1	0	1	0	1	0	0	0	0			
	1	0	0	1	1												
		1	0	1	0	1											
		1	0	0	1	1											
				1	1	0	0	1									
				1	0	0	1	1									
					1	0	1	0	0								
					1	0	0	1	1								
							1	1	1	1	0						
							1	0	0	1	1						
								1	1	0	1	0					
								1	0	0	1	1					
									1	0	0	1	0				
									1	0	0	1	1				
											0	**0**	**1**	**0**		←	**R**

Question # 8 (marks)

Consider the given table.

IP address Class	Leading bits in address (binary)	Range of first octet (decimal)	Network ID format	Host ID format	Number of networks	Number of addresses per network
A	0	0–127	a	b.c.d	$2^7 = 128$	$2^{24} = 16777216$
B	10	128–191	a.b	c.d	$2^{14} = 16384$	$2^{16} = 65536$
C	110	192–223	a.b.c	d	$2^{21} = 2097152$	$2^8 = 256$

If *Commerce Reyham* company wants to install a network of 700 computers, From the *class* point of view, what type of IP configuration do you suggest?

Using Class B IP addresses will waste a huge number of IPs.

Therefore, three (3) class C IP addresses should meet the needs of Commerce Reyham.

Question # 9 (marks)

In the 1970s ALOHA random access was employed in the Ethernet cable based network and then in the Marisat (now Inmarsat) satellite network. Assume that a certain node retransmits its frame 13.824 *msec* after experiencing few collisions (failures). Hint: Use a bit rate of 10Mbps for this network and think of finding *k*.

a) By what probability was this time (13.824 *msec*) chosen?

The bit time in this case is:
1/10Mbps = 10^{-7} seconds, or in other words 100 nano seconds.

Since packet shooting times are given as:
$512 \times k \times 100 \text{ x } 10^{-9} = 13.824 \text{ x } 10^{-3}$
Solving for k, we get:
$k = 13.824 \text{ x } 10^{-3} / (512 \times 100 \text{ x } 10^{-9}) = 270$

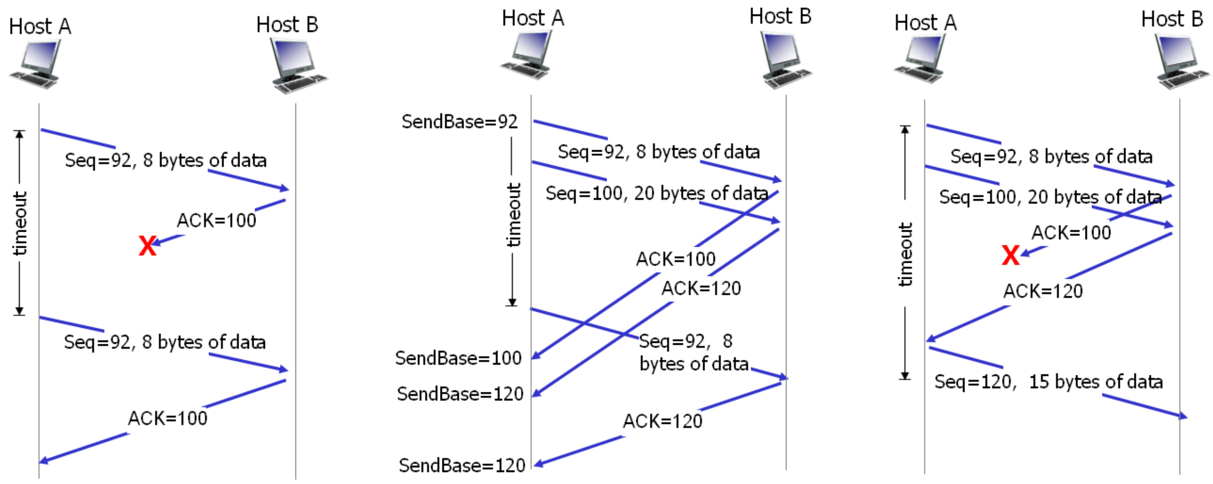
Since $256 \leq 270 \leq 512$ ➔ *k* is chosen with a probability of 1/512

b) Before this retransmission, how many failures had the switch experienced?

For *m* collisions, $k = 0, \ldots, 2^m$, Next shooting times: $512 \times k \times$ bit time (seconds).
Since $512 = 2^9$ ➔ *m* is 9 collisions

<u>Question # 10</u> (marks)

Consider the TCP transmissions shown.



a) Are these transmissions successful transmissions? Comment on each scenario (very briefly explain the action taken by TCP protocol, as shown in these figures).

First two cases are failed transmissions; therefore, a retransmission was necessary according to the reliable data transfer concept.

The third case is a successful transmission.

b) Indicate the exact name of each scenario?

<u>First case:</u> **ACKNOWLEDGEMENT LOST.**
Retransmission of seq=92 due to a lost acknowledgment, time-out is OK.

<u>Second case:</u> **PREMATURE TIMEOUT.**
Time-out is too short, segments seq=92 and seq=100 are retransmitted.

<u>Third case:</u> **CUMULATIVE ACKNOWLEDGMENT.**
First acknowledgement is lost, but second acknowledgement arrives within time-out period. Therefore, this is considered a successful transmission. No retransmission occurs.

Question # 11 (marks)
A host and server are located 4000km apart from each other and are connected via 1Gbps link.

If a stop-and-wait protocol is used, find:

a) The round trip time

Using $v = x/t$:

$$t_{RTT} = \frac{8\times10^6 m}{3\times10^8\ m/\sec} = \frac{8}{300} = 0.02667\sec = 26.67\ milli\sec = 26666.7\ micro\sec$$

b) The time needed to transmit a packet through the link.

Time needed to send one bit:

$$bit-time = \frac{1}{10^9\ bits/\sec} = 10^{-9}\ \sec = 1\ nano\sec$$

Time needed to send one packet:

$$d_{trans} = 9600\times bit\_time = 9600\ nano\sec = 9.6\ micro\sec$$

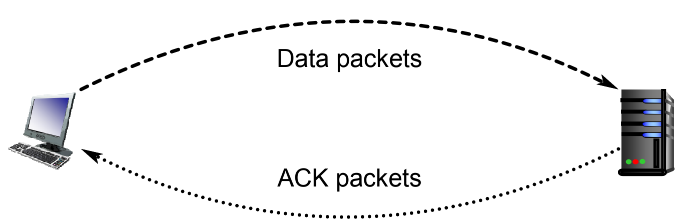
c) The utilization (fraction of time server is busy sending).

$$U_{sender} = \frac{d_{trans}}{d_{trans}+t_{RTT}} = \frac{9.6}{9.6+26666.7} = 3.6\times10^{-4} = 0.036\%$$

This is why stop-and-wait protocol is not a practical implementation!

d) What protocols are used to overcome this problem? (mention the names).

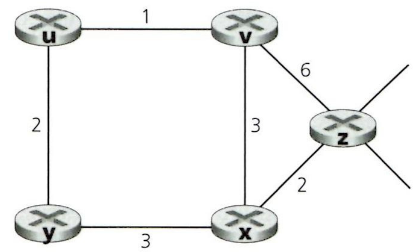
Go-back-N and Selective Repeat protocols are designed to overcome this problem.



Hints:
To calculate RTT use speed of light.
Assume 9600 bits / packet.

<u>Question # 12</u> (marks)

a) Consider the network shown and assume that each node initially knows the costs to each of its neighbors. Consider the distance vector algorithm and show the distance table entries at node *z*.



Cost to

		U	v	X	y	z
	V	∞	∞	∞	∞	∞
From	X	∞	∞	∞	∞	∞
	Z	∞	6	2	∞	0

Cost to

		u	**v**	**X**	**Y**	**z**
	V	**1**	**0**	**3**	∞	**6**
From	X	∞	**3**	**0**	**3**	**2**
	Z	**7**	**5**	**2**	**5**	**0**

Cost to

		u	v	X	y	z
	V	**1**	**0**	**3**	**3**	**5**
From	X	**4**	**3**	**0**	**3**	**2**
	Z	**6**	**5**	**2**	**5**	**0**

Cost to

		u	V	X	y	z
	V	**1**	**0**	**3**	**3**	**5**
From	X	**4**	**3**	**0**	**3**	**2**
	Z	**6**	**5**	**2**	**5**	**0**

b) Suppose that the information content of a packet is the bit pattern 1110 0110 1001 1101 and an even parity scheme is used. What would the value of the field containing the parity bits be for the case of a two-dimensional parity scheme? Your answer should be such that a minimum length checksum field is used.

1	1	1	0	**1**
0	1	1	0	**0**
1	0	0	1	**0**
1	1	0	1	**1**
1	**1**	**0**	**0**	**0**