THE UNIVERSITY OF QUEENSLAND

VENUE:	
SEAT NUMBER:	
STUDENT NUMBER:	

Sample Solution.

FINAL EXAMINATION

Second Semester, 2007

St Lucia Campus
Internal

COMS3200- Computer Networks I
COMS7201- Computer Networks I

PERUSAL TIME	**10mins. During perusal, write only on the scrap paper provided**
WRITING TIME	**120 Mins**
EXAMINER	**Professor Neil Bergmann**
	NO. OF PAGES (*include title page and attachments*) 14 Pages - Double-Sided

Exam Type:	**Open Book - Unrestricted Materials**
Permitted Materials:	**Calculator - Yes - Any type of calculator is permitted** **Dictionary - Yes - Any unmarked paper dictionary is permitted** **Other – No electronic aids are permitted (e.g. laptops, phone)** **Open Book – Unrestricted Materials**
Answer:	**On examination paper in spaces provided**
Number of Questions:	**Answer any 5 questions from the 6 questions provided.** **All questions are of equal value.**
Weighting/Marks:	**60 marks**
Special Instructions:	**Students must comply with the General Award Rules 1A.7 and 1A.8 which outline the responsibilities of students during an examination.**

THIS EXAMINATION PAPER MUST NOT BE REMOVED FROM THE EXAMINATION ROOM

WRITE ANSWERS ON THIS QUESTION PAPER IN THE SPACES PROVIDED

ANSWER ANY FIVE QUESTIONS

Question 1

(a) List two ways in which the OSI reference model and the TCP reference model are the same. [2 marks]

Both are layered

Network, Transport layers have similar functionality

Both designed to be implemented.

(b) List two ways in which the OSI reference model and the TCP reference model differ. [2 marks]

Number of layers

Number of protocols at different layers

TCP doesn't specify physical layer

OSI model has no widely used implementation.

(c) 802.11 is a networking standard developed by which body?[1 mark]

IEEE

.../cont

Question 1 (cont)

(d) Suppose a router has accepted flows with the TSpecs shown in the table below, described in terms of token bucket filters with token rate r packets per second and bucket depth B packets. All flows are in the same direction and the router can forward one packet every 50 ms. ≈ 20 packets per sec.

Flow	r	B
X	2	10
Y	6	4
Z	10	10

(i) What is the maximum delay a packet might face? [2 marks]

If all buckets dumped at same time, puts 10+4+10 = 24 packets. $\frac{24p}{20pps}$ = 1.25

(ii) What is the average number of packets from flow X that the router would send every 10 seconds? [2 marks]

average = $r_X * t$ = 2 × 10 = 20 packets

(iii). What is the minimum number of packets from flow Z that the router would send over 2 seconds, assuming that the flow sent packets at its maximum rate uniformly? [3 marks]

Maximum sent by a flow, F, in t seconds is:-

$Max_F = B_F + r_F * t$

So $Max_X = B_X + r_X * t = 10 + 2*2 = 14$

$Max_Y = B_Y + r_Y * t = 4 + 2*6 = 16$

so $Max_X + Max_Y = 30$

In 2 secs, can send 40

so $Min_Z = 10$

Note: Tut 11, Q3 would give a different answer, 18, but I think it is wrong. Either answer would get full marks

Question 2

(a) An RPC protocol is used to implement a database access system such as a library catalog system.

(i) For which (one or more) of the following RPC semantics would an idempotent procedure always work correctly: zero-or-more, at-least-once, at-most-once, exactly-once? [2 marks]

at least once, exactly once.

(ii) Give a clear and unambiguous example of an idempotent library catalog* database access request. [1 mark]

Return the title for a given call number

OR Return the loan status for a book.

(iii) Give a clear and unambiguous example of a non-idempotent library catalog database access request. [1 mark]

Check out a book if it is not checked out, otherwise give an error if it is checked out.

(b) Perform encryption and decryption using RSA as explained in lectures for the following: p=7, q=13, e=29: [6 marks]

ed mod z = 1

d	ed mod z
1	29
2	58
3	15
4	44
5	1

(i) z= $(p-1)(q-1) = 72$ (ii)d= 5

$n = pq = 91$

(iii) If Plaintext M=2, Ciphertext C= $M^e \bmod n = 2^{29} \bmod 91 = 32$

(iv) If Ciphertext C = 16, Decrypted Plaintext M= $C^d \bmod n = 16^5 \bmod 91 = 74$

(c) In network security, what is a hash function such as MD5 used for? [2 marks]

It is used to create a message digest for message authentication.

* Assignment in 2007 was a library catalog example.

Question 3

(a) You are hired to design a reliable byte-stream protocol that uses a sliding window (like TCP). This protocol will run over a 1Mbps network. The round-trip-time (RTT) of the network is 500ms, and the maximum segment lifetime (MSL) is 100 seconds.

(i) How many bits would you include in the AdvertisedWindow field of your protocol header? [1 mark]

16 bits

(ii) How many bits would you include in the SequenceNumber field of your protocol header? [1 mark]

24 bits

(b) Why does the TCP checksum calculation violate a strict layered protocol hierarchy? [2 marks]

The checksum uses the IP address as part of pseudoheader, and this is not part of TCP packet.

(c) Name one other feature of modern IP-based computer networks which violates the strict layered protocol hierarchy. [2 marks]

- NAT changes IP address and port address so it changes transport layer, but it is a network layer function.
- IP fragmentation changes network packets based on link layer constraints

../cont

a i) AW should keep link full
delay (RTT) x bw = 500ms x 1Mbps = 500kb
= 62500 B. # 2^{15} = 32768 2^{16} = 65536

ii) SEQNO should not wrap in MSL
100s x 1Mbps = 100Mb = 12.5MB
2^{23} = 8.3MB 2^{24} = 16.7MB ⇒ 24 bit

Question 3 (cont)

(d) You are designing a new format for audio disks based on next generation BluRay optical disks. Each disk can hold 25 gigabytes (25×10^9 bytes) of data.
Assume:

The audio sampling rate is 48 kHz.
There are two audio channels (left and right).
For each sample, each channel uses 16 bits PCM coding plus 8 bits for error correction.
There is no compression.
5% of the disk capacity is reserved for directory information.

How many hours of music can such a disk hold? [2 marks]

22.9 hr.

(e) An audio streaming server has a one-way distance of 50 ms for data from the server to the media player, once the server receives a pause or resume message . The delay for pause or resume control information from the media player back to the streaming server is 100ms.
The server outputs at 2 Mbps. Assume playout also at 2Mbps
The media player has a 1 Mbyte buffer.

(i) What is the minimum value for the low-water mark? [2 marks]

37,500 B

(ii) What is the maximum value for the high water mark? [2 marks]

1,011,076 B (= 1MB − 37,500B)

d) 3 byte/sample × 48 ksample/sec × 2 channels × 3600 sec/hr

= 1.0368 GB

Length = $\frac{95\% \times 25\text{GB}}{1.0368}$ = 22.9

e) i) RTT = 150ms = 0.15s

low-water mark = RTT * playout = 0.15s × 2Mbps
= 300,000 b = 37,500 B

high-water mark = MAX − (RTT * server speed)
= 1MB − 0.15 * 2Mbps = 1M − 37,500B

Question 4

(a) An FM radio channel is 100 kHz wide. What's the maximum bit-rate (bps) which can be sent if 16-level digital signals are used? Assume a noiseless channel. [1 mark]

Nyquist ⇒ 200k symbol/sec × 4 bit/sym = 800,000 bps

(b) An FM radio channel is 100 kHz wide. What's the maximum bit-rate (bps) which can be sent if the signal-to-noise ratio is 20 dB? [2 marks]

666 k bps

(b) An FM radio channel is 100 kHz wide. What's the maximum bit-rate (bps) which can be sent if the signal-to-noise ratio is 0 dB? [2 marks]

100 kbps

...cont/

b) Shannon Data Rate = $W \log_2(1+\frac{S}{N})$

20dB ⇒ $\frac{S}{N} = 100$

0dB ⇒ $\frac{S}{N} = 1$

b): $100k \log_2 101 = 100k \times 6.66$

c) $100k \log_2 2 = 100k$.

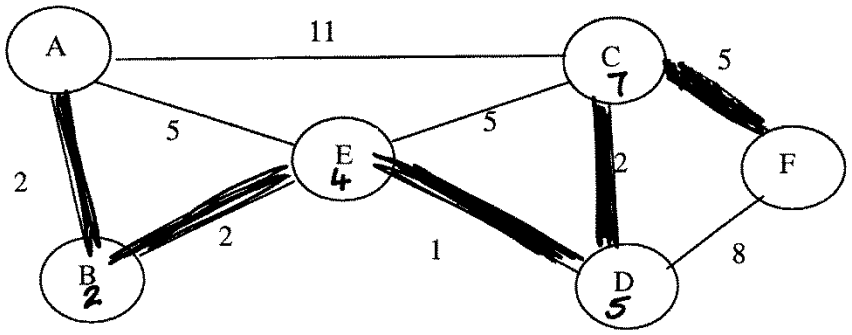
Question 4 (cont)

(c) Given the network below and using the metrics shown on the links as the basis for optimality:

(i) Complete the following table showing the distance of each node from A after each step of Dijkstra's algorithm. Permanent labels should be shown as circled in the table. [2 marks]

	Distance from A to Node ...				
Step	B	C	D	E	F
1	(2)	11	∞	5	∞
2				(4) B	
3		9	(5) E		
4		(7) D			13
5					(12) C

(ii) Sketch the shortest path from A to F using Dijkstra's algorithm on the diagram below. [2 marks]

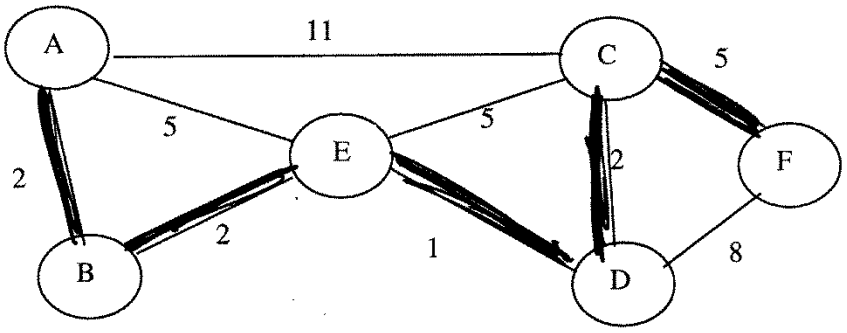


A B E D C F

.../cont

Question 4 (c) (cont)

(iii) Show the spanning tree rooted at A which is formed by the application of Dijkstra's algorithm from part (i) (make sure your sketch clearly shows which links are on the tree and which are not).
The metrics are the same in each direction on the link.
(Note that the two diagrams in (i) and (ii) are the same). [3 marks]



AB
BE
ED
DC
CF

(same as ii occurs because path A-F happens to include every node)

Question 5

(a) A cyclic redundancy code has 12 message bits and uses the generator polynomial to produce an 8-bit CRC field:

$x^7 + x^6 + x + 1$

Deduce the redundant checkbits which would be appended to the following message at the sender side: 110011001101. [4 marks]

110011001101 0111101

(b) The following bits are transmitted on a link which uses HDLC framing and bit stuffing. What data is passed to the receiver after bit stuffing and framing has been removed. [2 marks]

Framed and Bit-stuffed:

stuffed bits

frame

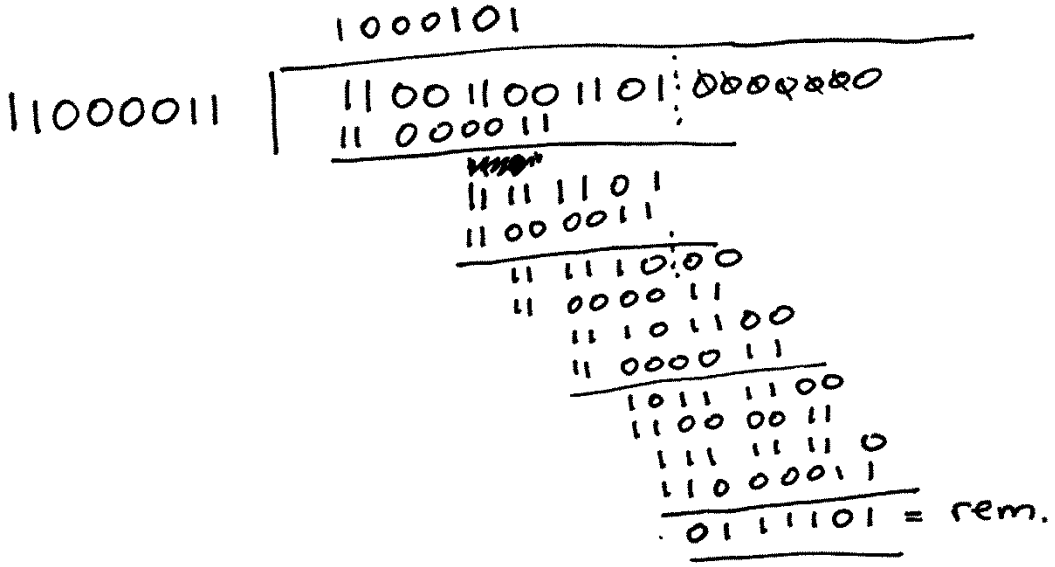
01111110111110111110000001111011111010011110111110

frame

After framing and bit stuffing removed at receiver:

11111 11111 00000 11110 11111 10011111

.../cont



Question 5 (cont)

(c) Suppose that a TCP message that contains 3000 bytes of data and 20 bytes of TCP header is passed to IP for delivery across three networks on the Internet (i.e., from the source host to a router to another router to the destination host). The first network has an MTU of 1500 bytes; the second has an MTU of 576 bytes, and the third network has an MTU of 1500 bytes. (The MTU is the largest IP frame payload, including any IP header). Give the size, offset and MF flag (1 or 0) fields of the sequence of fragments delivered to the network layer at the destination host. Assume all IP headers are 20 bytes. [4 marks]

Size	Offset	MF
572	0	1
572	69	1
396	138	1
572	185	1
572	254	1
396	323	1
80	370	0

MTU 1500
⇒ 20 header
+ 1480 payload
(= 185 * 8)
MTU 576
⇒ 20 header
+ 552 payload
= 69 * 8
(4 bytes unused.

3020
↓
1480 ← 552 552 376
+ 1480 ← 552 552 376
+ 60
then
1480 → 552+ 552+ 376
then add header
⇒ 572 +572 +396

(d) (i) Convert the IP address whose hexadecimal representation is 822C158A to dotted decimal notation. [1 mark]

130.44.21.138

(ii) What class of network does this belong to? [1 mark] B

Question 6

(a) Consider a baseband bus with a number of stations.
Assume

- an average distance between stations of 100m
- a maximum distance between stations of 250m
- a propagation speed of 200,000 km per second
- a data rate of 10 Mbps
- a CSMA/CD access method based on the IEEE 802.3 standard

(i) What is the average time to send a packet of 1500 bits to another station, measured from the beginning of the transmission to the end of reception, assuming no collision? [1 mark]

Tx + PROP 100m = 150.5μs

(ii) If two stations begin to transmit at exactly the same time, how long will it take on average before they notice a collision, in seconds? [1 mark]

PROP 100m = 0.5μs

(iii) If one station starts transmitting, what is the time after which the station knows that it seized the channel (i.e. there will not be any collision during this transmission)? [2 marks]

2x PROP 250m = 2.5μs

(iv) What is the minimum packet size to ensure collision detection works correctly? [2 marks]

bits for iii) 25 bits (or 4 bytes would be acceptable).

.../cont

(i) transmission time = $\frac{1500 \text{ bits}}{10 \text{ Mbps}}$ = 150μs

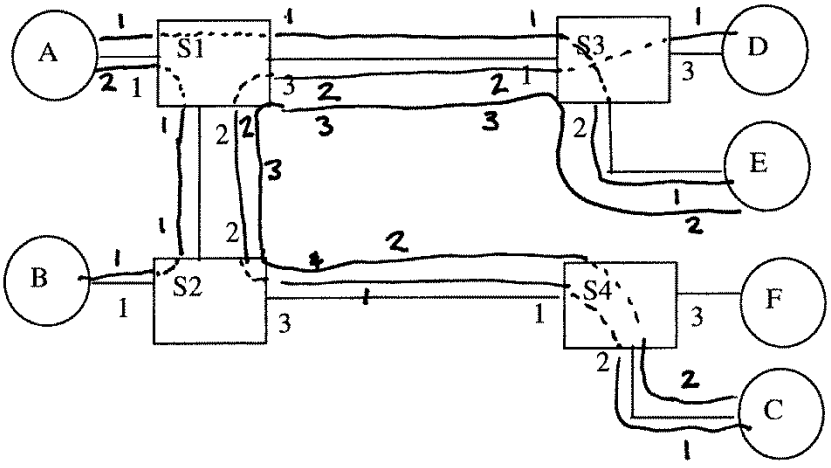
Prop time for 100 m = $\frac{100 \text{ m}}{2 \times 10^8 \text{ m/s}}$ = 0.5μs

(iii)
2x max Prop time = 500 m ⟹ 2.5μs

2.5μs × 10 Mbps = 25 bits

Question 6 (cont)

(b) Consider the connection-oriented (virtual circuit) switches in the figure below. The connection tables lists, for each switch, what <port, Connection-Identifier> pairs are connected to what other. Connections are bidirectional. Hosts are shown as round nodes, switches are shown as rectangular nodes, with switch port numbers shown at the end of each link.



Switch S1			
Port	CI	Port	CI
1	1	3	1
1	2	2	1
2	2	3	2
2	3	3	3

Switch S3			
Port	CI	Port	CI
1	1	2	1
1	2	3	1
1	3	2	2

Switch S2			
Port	CI	Port	CI
2	1	1	1
3	1	2	2
3	2	2	3

Switch S4			
Port	CI	Port	CI
2	1	1	1
2	2	1	2

(i) Add extra connection table entries to the tables above to add a new connection between C and E. Assume that the connection identifier (CI) assignment always picks the lowest unused CI on each link, starting with 1. [3 marks]

...cont/

Question 6(b) (cont)

(ii) List all endpoint-to-endpoint connections in the table below.
The connection from part (i) has already been added. [3 marks]

End Point	Endpoint
C	E
A	E
A	B
C	D

END OF PAPER