UNIVERSITÉ YORK UNIVERSITY

Department of Computer Science and Engineering

COSC 4213: Computer Networks II (Fall 2006)

Instructor: N. Vlajic

Date: October 24, 2006

Midterm Examination

Instructions:

- Examination time: 75 min.
- Print your name and CS student number in the space provided below.
- This examination is closed book and closed notes.
- There are 6 questions. The points for each question are given in square brackets, next to the question title. The overall maximum score is 100.
- Answer each question in the space provided. If you need to continue an answer onto the last page, clearly indicate that and label the continuation with the question number.

FIRST NAME: ______________________

LAST NAME: ______________________

STUDENT #: ______________________

Question	Points
1	/ 20
2	/ 20
3	/ 10
4	/ 20
5	/ 15
6	/ 15
Total	/ 100

1. Multiple Choice **[20 points]** *time: 15 min*

Circle the correct answer(s) for the following statements. For each statement, you will obtain 0 marks if the number of circled answers is more/less than appropriate.

(1.1) TCP/IP Model
In the TCP/IP model, encryption and decryption are functions of ______________ layer .

(a) data-link

(b) network

(c) transport

(d) application

(1.2) Ethernet Addressing
Ethernet uses ______________ physical addresses that are imprinted on computers' network interface cards (NICs).

(a) 32-bit

(b) 64-bit

(c) 6-byte

(d) none of the above

(1.3) IP Addressing
Which of the following is true for the IP address 231.1.2.3?

(a) the netid is 231.1.2

(b) the class is D

(c) the hostid is 1.2.3

(d) none of the above

(1.4) IP Addressing
A host with an IP address of 142.5.0.1 needs to test internal software. Which of the following addresses could be used as the destination address in the packet?

(a) 1.1.1.1

(b) 127.1.1.1

(c) 142.0.0.0

(d) none of the above

(1.5) IPv6

Suppose one IPv6 router wants to send a datagram to another IPv6 router, but the two are connected via intermediate IPv4 routers. If the two IPv6 routers use tunnelling, then:

(a) the sending IPv6 router creates an IPv4 datagram and puts it in the data field of an IPv6 datagram

(b) the sending IPv6 router creates one or more IPv6 fragments, non of which is larger than the maximum size of an IPv4 datagram

(c) the sending IPv6 router creates an IPv6 datagram and puts it in the data field of an IPv4 datagram

(d) the sending IPv6 router creates an IPv6 datagram and intermediate IPv4 routers will reject the IPv6 datagram

(1.6) ICMP Protocol

Who can send ICMP error reporting messages?

(a) routers

(b) hosts

(c) a and b

(d) none of the above

(1.7) Multicast / Broadcast

In ____________________ , the router always forwards the received packet through only one of its interfaces.

(a) broadcasting

(b) multicasting

(c) a and b

(d) none of the above

(1.8) IGMP Protocol

An IGMP packet is carried in an ______________________ packet .

(a) Ethernet frame

(b) ICMP

(c) IP

(d) UDP

(1.9) Unicast Routing

In Distance Vector routing, each node periodically shares its routing table with ________________ and whenever there is a change.

(a) every router in the network

(b) its immediate neighbours

(c) one neighbour

(d) none of the above

(1.10) TCP Protocol

The inclusion of the checksum in the TCP segment is __________________ .

(a) optional

(b) mandatory

(c) at the discretion of the application program

(d) none of the above

2. Queueing Theory / Packet Switching [20 points] *time: 15 min*

Let us consider a simple packet-switching system as shown in the figure below.

- The path from sender A to receiver B passes through two intermediate routers.
- Each router has an input queue of size 1 [Mbit].
- The three links support the same data rate R=10 [kbps].
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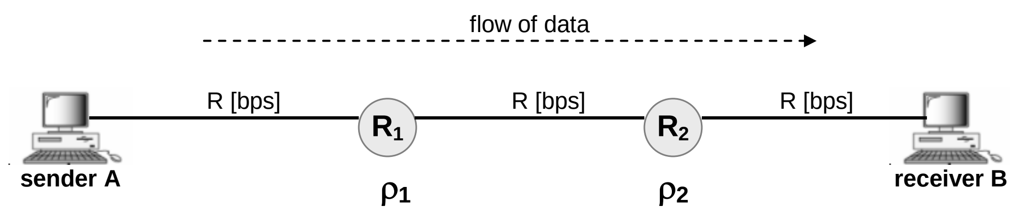
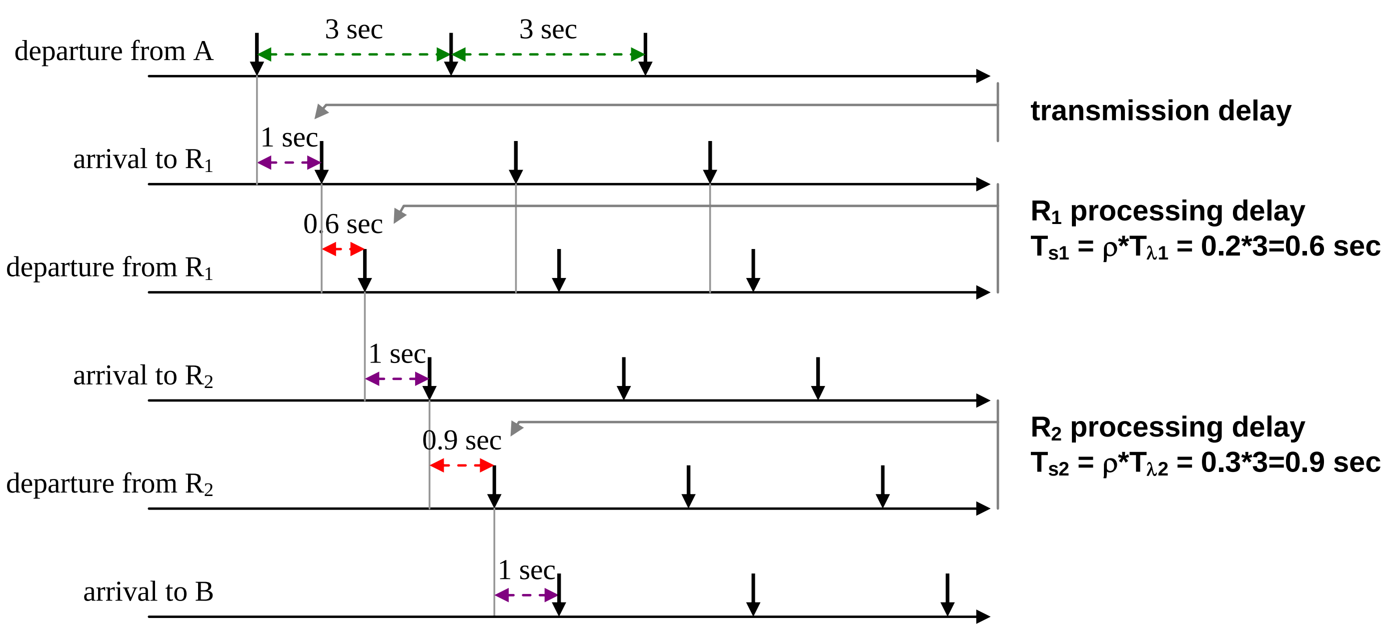
<u>In all the subsequent questions, show your work to receive credit!</u>



(a) [6 points] Assume the utilization of the first router (R_1) is $\rho_1 = 0.2$, the utilization of the second router is $\rho_2 = 0.3$, and sender A generates and sends one packet of size 10 [kbit] every 3 seconds. What is the rate at which packets arrive at receiver B?

arrival rate to R_1 = departure rate from A
arrival rate to R_2 = departure rate from R_1
arrival rate to B = departure rate from R_2



The arrival rate to B is the same as the departure rate from A = 1/3 [packet/sec] or A = 3.33 [kbit/sec].

(b) [6 points] The assumptions remain the same as in (a); except, sender A generates and sends only 3 packets in total. What is the overall time required to deliver these three packets to receiver B? (Propagation delay can be ignored on all three links.)

Based on the above picture, the overall delay = 6 [sec] + time to deliver last packet

Time do deliver last packet = $d_{trans.}(A,R_1) + d_{proc.}(R_1) + d_{trans.}(R_1,R_2) + d_{proc.}(R_2) + d_{trans.}(R_2,B)$ =
= 1 sec + 0.6 sec + 1 sec + 0.9 sec + 1 sec = 4.5 [sec]

overall delay = 10.5 [sec]

(c) [5 points] The assumptions are the same as in (a); except, the utilization of the second router (R_2) changes to $\rho_2 = 1.2$. What is the rate at which packets arrive at receiver B in this case?

In this case, R_2 is clearly a 'bottleneck' – its slow processing (i.e. its long service time of Ts_2 = 1.2*3 [sec] = 3.6 [sec]) dictates the packet departure rate, i.e. the packet arrival rate at B.

Hence, arrival rate at B = $1/Ts_2$ = 1/3.6 [packets/sec] = 2.7 [kbit/sec]

(d) [3 points] The assumptions remain the same as in (c). What are the maximum size to which queues in routers R1 and R2 grow? (Answer for each queue individually.)

R1: Based on the above picture, it is clear that packets always arrive to 'idle' R1. This, and ρ_1 = 0.2, suggest that the size of R1 queue remains 0 at all times.

R2: ρ_2 = 1.2 suggests that R2 is over-utilized. Accordingly, we conclude - the size of R2 queue will keep growing until reaches its maximum. After that point, newly arrived packets will have to be dropped.

3. Subnetting **[10 points]** *time: 10 min*

An organization has been assigned the network address: 140.25.0.0, and it needs to create a set of subnets that support up to 25 hosts on each subnet.

(a) [4 points] What is the subnet mask you would use to do this?

140.25.0.0 – class B address ⇒ available bits in hostID part = 16

required No. of hosts = 25, $2^4<25<2^5$ ⇒ required No. of bits in new hostID = 5
required No. of bits in subnet ID = 11

subnet mask: 255.255.255.224, or 11111111 11111111 11111111 11100000

(b) [3 points] What is the maximum possible number of such subnets in the given network? The use of special address must be avoided!

Number of subnets = $2^{11} – 2 = 2046$

(c) [4 points] Given that there are 25 hosts on each subnet, how much of the address space is being wasted (in percentages)?

Instead of $2^5 - 2 = 30$ hosts, each subnet uses only 25 hosts.

So, in each subnet 5 addresses are not used.

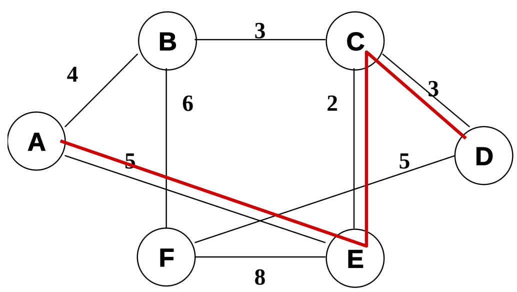
Wastage=5/30=1/6=16.67%

4. Routing **[20 points]** *time: 15 min*

(a) [12 points] The nodes participating in the Link State algorithm in one network are broadcasting the following link-state packets. Based on these packets,

- Draw the network topology and assign link costs.
- Run the Link State (Dijkstra) algorithm to determine the shortest path from D to A. (Clearly specify what this path is.)

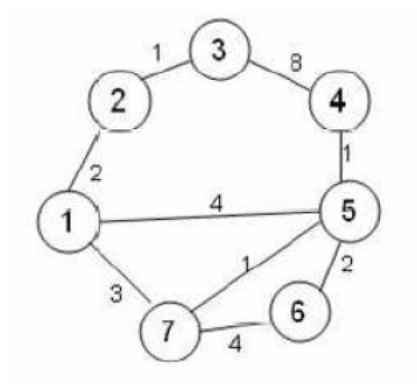
Router B		Router C		Router D		Router E		Router F	
A	4	B	3	C	3	A	5	B	6
C	3	D	3	F	5	C	2	D	5
F	6	E	2			F	8	E	8



step	N	D(A),p(A)	D(B),p(B)	D(C), p©	D(E),p(E)	D(F),p(F)
0	D	infty	infty	3,D	infty	5,D
1	DC	infty	6,C		5,C	5,D
2	DCE	10,E	6,C			5,D
3	DCEF	10,E	6,C			
4	DCEFB	10,E				
5	DCEFBA					

.

(b) [8 points] Consider a network topology as shown in the picture, and a synchronous version of distance vector algorithm (in one iterative step all the nodes compute their distance tables at the same time and then exchange them). Suppose that at each iteration, a node exchanges its minimum cost with its neighbours and receives their minimum cost. Assuming that the algorithm begins with each node knowing only the cost to its immediate neighbours, what is the maximum number of iterations required until the distributed algorithm converges?



Convergence time = length of the longest HOP-path (without loops) between any two nodes in the network.

Max distance from 1: 2
Max distance from 2: 3
Max distance from 3: 3
Max distance from 4: 2
Max distance from 5: 2
Max distance from 6: 3
Max distance from 7: 3

Hence, we can expect that the algorithm converges after 3 iterations.

5. Multicasting **[15 points]** *time: 10 min*

(a) [10 points] Suppose two multicast groups (A, B) are formed and get to choose their multicast addresses at exactly the same time. The groups choose their respective multicast addresses, from the pool of all available multicast addresses, randomly and independently of each other.

Now, assume we know group A has picked the following multicast address: 224.7.7.7. What is the probability that group B chooses the same address?

244.0.0.0 = 1110 | 0000 00000000 00000000 00000000
239.255.255.255 = 1110 | 1111 11111111 11111111 11111111

32 - 4 = 28 bits are available for multicast addresses.

Thus, the size of the multicast address space is $N = 2^{28}$.

The probability that group B chooses the same address: $p_2 = \frac{1}{N} = 2^{-28}$

(b) [5 points] A system uses Reverse Path Forwarding (RPF) algorithm to build multicast trees and deliver multicast packets. There are 100 multicast sources (each generating a single stream of multicast traffic) and 5 groups currently active in the system. What is the number of RPF multicast trees existing in the system?

RPF is a source-based multicast routing algorithm. Hence, there is one tree per each active source, or 100 RPF trees in total.

6. IP Fragmentation [15 points] *time: 10 min*

An IP datagram carrying 10000 bytes of data must be sent over a link (i.e. network) that has an MTU of 4468 bytes. Assume the datagram has no Options, and the Identification number is 218.

How many fragments will be generated?
State the values (in decimal numbers) of the following fields for each of the fragments:
Identification, Total Length, D-bit, M-bit, Fragmentation Offset.

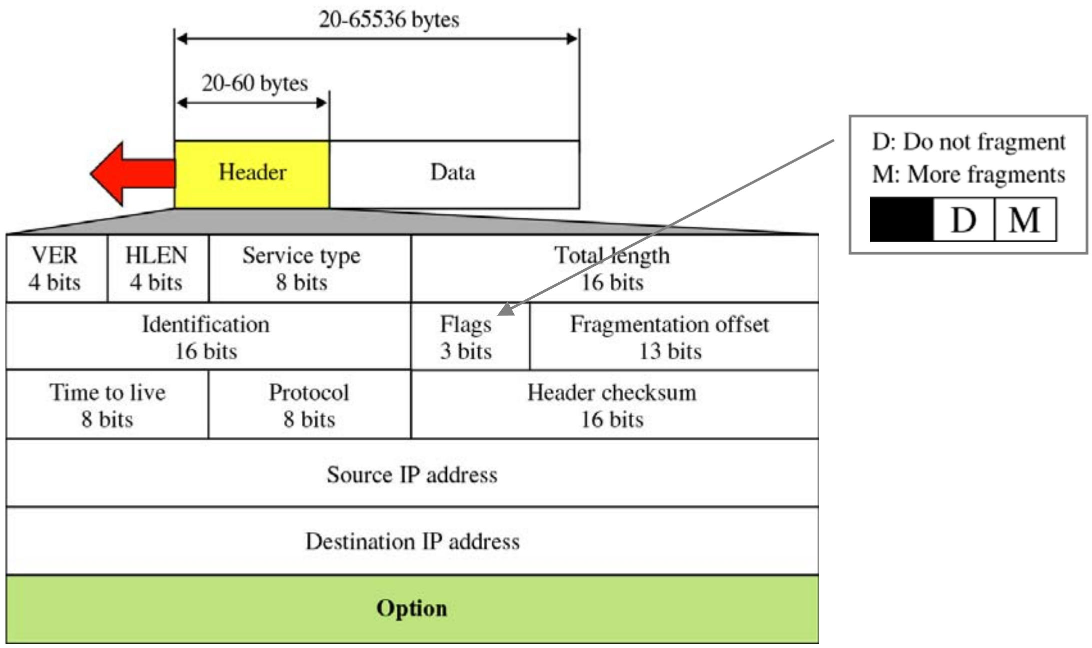
The format of the IP header is shown on the subsequent page.

3 fragments.

1st fragment : 4448 +20 bytes
2nd fragment: 4448 +20 bytes
3rd fragment: 1104 +20 bytes

	First	Second	Third
IDENTIFICATION	218	218	218
TOTAL LENGTH	4468	4468	1124
DNF	0	0	0
MF	1	1	0
FRAGMENT OFFSET	0	556	1112

http://web2.uwindsor.ca/courses/cs/aggarwal/cs60375/papers/MidTerm1_1.doc


20-65536 bytes
20-60 bytes
Header
Data
D: Do not fragment
M: More fragments
D
M
VER
4 bits
HLEN
4 bits
Service type
8 bits
Total length
16 bits
Identification
16 bits
Flags
3 bits
Fragmentation offset
13 bits
Time to live
8 bits
Protocol
8 bits
Header checksum
16 bits
Source IP address
Destination IP address
Option