UNIVERSITY OF VICTORIA
EXAMINATIONS
COMPUTER COMMUNICATIONS NETWORKS
ECE458 (2019) - Midterm spring 2019

NAME: [redacted]
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DURATION: 70 minutes

STUDENT NO.: [redacted]
SECTION:

TO BE ANSWERED ON PAPER

IMPORTANT NOTICE: STUDENTS MUST COUNT THE NUMBER OF PAGES IN THE QUESTIONS PAPER BEFORE BEGINNING TO WRITE, AND REPORT ANY DISCREPANCY IMMEDIATELY TO THE INVIGILATOR.

THIS QUESTIONS PAPER HAS EIGHT (8) PAGES INCLUDING THIS COVER PAGE.

This is an open-book exam. Books and notes are allowed.

Non-programmable calculator with no network connectivity is allowed.

Check the units of your answers.

Please read all questions and [marks] assigned to each question. Total marks: 30

Question	1	2	3	4	5	Total
Earned Marks						

1. There is a communication link with the data rate of $R = 100$ Mbps connecting two hosts, A and B. The link length is 30 kilometres. The propagation speed is assumed 3×10^8 meters/sec.
   (a) What is the propagation delay of the communication link? [2]
   (b) What is the transmission time of a packet of 1250 bytes (=10000 bits) over the link? [2]
   (c) Suppose host A transmits a packet of 1250 bytes to host B. When the first bit of the packet just arrives host B, where is the last bit of the packet? [2]

a) $d_{prop} = \frac{\text{dist}}{\text{speed}} = \frac{30 \times 10^3 \text{ m}}{3 \times 10^8 \text{ m/s}} = \boxed{1 \times 10^{-4} \text{ seconds}}$

b) $d_{trans} = \frac{\text{length}}{\text{bandwidth}} = \frac{10000 \text{ bits}}{100 \times 10^6 \text{ bits/second}} = \frac{10^4}{10^8} \text{ seconds} = \boxed{1 \times 10^{-4} \text{ seconds}}$

c) It took 10^{-4} seconds to arrive after the time it took to be transmitted. So the last bit has just been transmitted (put into the link) when the first bit arrives at host B.

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2. A character is represented in its binary format: `1011111`.

   (a) Please write down the character in Hamming coded format with even parity. [3]

   (b) Given the generator polynomial $x^3 + x^2 + 1$, please write down the CRC-appended bit string of the **above Hamming coded** character. [3]

a)

bit	1	2	3	4	5	6	7	8	9	10	11
1-parity	0	–	1	–	0	1	1	–	1	1	1
2-parity	–	1	1	–	0	1	1	–	1	1	1
4-parity	–	–	1	0	0	1	1	–	1	1	1
8-parity	–	–	1	–	0	1	1	1	1	1	1

$\Downarrow$

Hamming-coded format with even parity produces $\boxed{01100111111}$

b) CRC with $x^3+x^2+1 \Rightarrow G = 1101$, $r=3$. $D = 01100111111$

Calculating R:

```
          0 1 0 0 1 0 1 1 1 0 0 0
1101 | 0 1 1 0 0 1 1 1 1 1 1 0 0 0
         1 1 0 1
         -------
           0 0 1 1 1 1
               1 1 0 1
               -------
                 0 1 0 1 1
                   1 1 0 1
                   -------
                     1 1 0 1
                     1 1 0 1
                     -----------
                     0 0 0 0 0 0 → remainder 000
```

So the appended bit string is $\boxed{000}$, so the entire string is 01100111111000.

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3. Please answer the following questions.

   (a) Explain why slotted Aloha can achieve a higher channel utilization than pure Aloha. [3]

   (b) Explain why CSMA/CD is typically more efficient than slotted Aloha in local area networks. (Hint: What are the differences? Why they are helpful?) [4]

a) With slotted ALOHA, a node only starts to transmit at the start of a slot. Thus, interference only occurs if another node starts to transmit in the same slot; that is, with slot size T, interference only occurs with those nodes that had frames arrive for transmission between t_0-T and t_0, where t_0 is the start of the slot.
However, for unslotted ALOHA, a node can start to transmit at any time. Thus, interference occurs if another node was already transmitting or if another node starts to transmit during a node's transmission. That is, with all packets taking T time to transmit, a node that starts to transmit at time t_0 will have interference with any other node that has nodes arrive for transmission between t_0-T and t_0+T, ~~which is twice the amount of time for~~

$(t_0+T)-(t_0-T) = 2T = 2((t_0)-(t_0-T))$, so the amount of time in which a pure ALOHA transmission can be interfered with is double the amount of time that a slotted ALOHA transmission can be interfered with. This is why slotted ALOHA can achieve higher channel utilization than pure ALOHA (and because when two frames interfere, that time is wasted in both protocols).

b) CSMA/CD is typically more efficient than slotted ALOHA for a few reasons:

- CSMA/CD has nodes stop transmitting immediately upon CD; slotted ALOHA always transmits the whole frame.

excellent!

- CSMA/CD nodes refrain from transmitting until they sense the channel is idle; slotted ALOHA simply transmits during the first slot occurring. Thus CSMA/CD has fewer collisions, especially during long transmissions
- CSMA/CD using binary exponential backoff to determine how long to wait before retransmitting a collision; slotted ALOHA simply retransmits with probability p in each slot. This makes CSMA/CD have fewer collisions when the channel is very busy overall.

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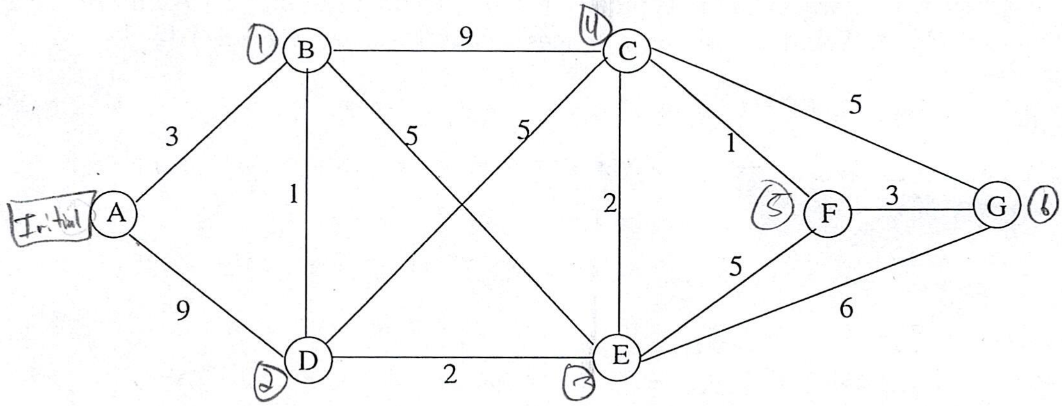
These are some of the reasons (among others) that Ethernet uses CSMA/CD over slotted ALOHA and are reasons that CSMA/CD is more efficient than slotted ALOHA.

4. In the following graph that represents the topology of a network, vertexes represent network routers, and edges represent bidirectional, symmetric communication links and are labeled by the router-to-router cost.



With link state routing, please find the paths with the least cost from router A to all other routers, respectively. **You need to show each step of your work using the following table.** [6]

Iterations	B	C	D	E	F	G
Initially	(3, A)	(∞, .)	(9, A)	(∞, .)	(∞, .)	(∞, .)
1	(3, A)	(12, B)	(4, B)	(8, B)	(∞, .)	(∞, .)
2	(3, A)	(9, D)	(4, B)	(6, D)	(∞, .)	(∞, .)
3	(3, A)	(8, E)	(4, B)	(6, D)	(11, E)	(12, E)
4	(3, A)	(8, E)	(4, B)	(6, D)	(9, C)	(12, E)
5	(3, A)	(8, E)	(4, B)	(6, D)	(9, C)	(12, E)
6	(3, A)	(8, E)	(4, B)	(6, D)	(9, C)	(12, E)

The least cost **path** from A to other routers are:

3 From A to B: A → B

8 From A to C: A → B → D → E → C

4 From A to D: A → B → D

6 From A to E: A → B → D → E

9 From A to F: A → B → D → E → C → F

12 From A to G: A → B → D → E → G

(or) A → B → D → E → C → F → G

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5. An IP packet (with no IP options) has the size of 3000 bytes. The packet has the source IP address of 142.104.81.63 and the destination IP address of 216.58.218.163.

   (a) After the packet has been forwarded through a link with the maximum transmission unit (MTU) of 1500 bytes (i.e., the maximum IP packet size supported by the link is 1500 bytes), please write down the "IP Header Length (IHL)", "Total length", "Fragment offset" and "More Fragment (MF)" of all IP fragments of the original 3000-byte IP packet. [3]

   (b) A router received this packet has the following forwarding table. Which output interface the router should choose to send out the above fragments? [2]

Destination network	Netmask	Output interface
142.104.64.0	19	1
142.104.80.0	20	2
216.58.216.0	21	3
216.58.220.0	22	4
...	...	...

a) Split 20 header + 2980 data into
- 20 header + 1480 data, offset 0, MF=1
- 20 header + 1480 data, offset 1480, MF=1
- 20 header + 20 data, offset 2960, MF=0

So

Fragment A:
IHL = 5
Total Length = 1500
Fragment offset = 0
MF = 1

Fragment B:
IHL = 5
Total Length = 1500
Fragment offset = 1480
MF = 1

Fragment C:
IHL = 5
Total Length = 40
Fragment offset = 2960
MF = 0

b) destination: 216.58.11011010.163
masks: interface 3: 216.58.11011000.0/21
interface 4: 216.58.11011100.0/22

The destination IP address matches the subnet mask for interface $\boxed{3}$, so this is where the router should send the above fragments.

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— END —