NATIONAL UNIVERSITY OF SINGAPORE

FINAL ASSESSMENT FOR
CS2105 – INTRODUCTION TO COMPUTER NETWORKS

(Semester 2: AY2016/2017)

Time allowed: 2 hours

INSTRUCTIONS TO CANDIDATES

1. This assessment paper contains **SIX** questions and comprises **FOURTEEN** printed pages.
2. This is an **OPEN BOOK** assessment. The maximum possible score is **55 marks**.
3. Calculators are allowed, but not laptops, PDAs, or other electronic devices.
4. Fill in your student number clearly below.

STUDENT NO: | | | | | | | | | |

For examiners' use only							
Question	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Total**
Max	**11**	**7**	**7**	**12**	**9**	**9**	**55**
Score							

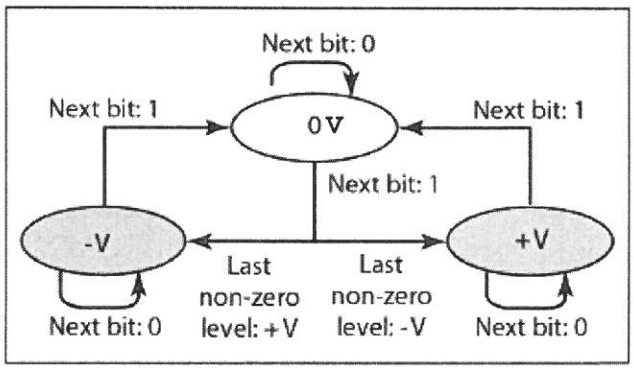
For Q2-Q6, write your answers within the space provided in each question.

Q2. **[Total: 7 marks]**

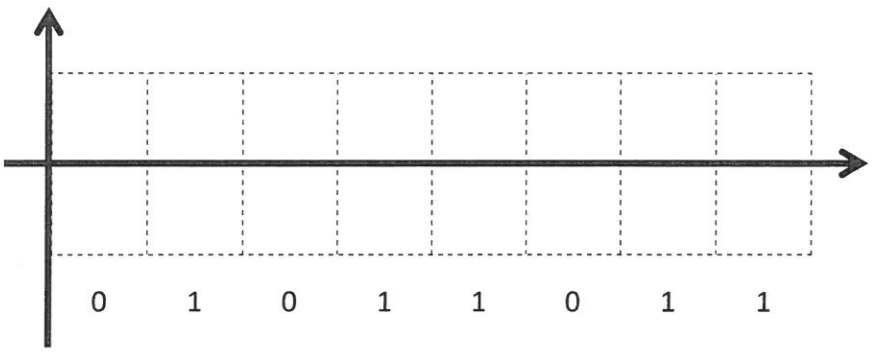
(a) **[2 marks]** Consider a noisy channel with a Shannon capacity of 50 Kbps and a bandwidth of 10 KHz. What is the SNR of this channel?

(b) **[2 marks]** A CSMA/CD network spans 2000 meters. The minimum frame size required for this network is 40 bits. Suppose the speed of electromagnetic wave is $2 * 10^8$ meters/s, what is the maximum data rate of this network?

(c) **[3 marks]** MLT-3 (Multi-level transmit, three levels) is a digital encoding method that uses three voltage levels. The encoding rules are shown in the transition diagram on the right. Draw the time domain graph below for the bit pattern **01011011**.



You may assume that the state prior to the bit pattern is "state 0" and the last non-zero level is +V.



Q3. Keep your answers accurate and concise. **[Total: 7 marks]**

(a) **[2 marks]** Name an application that uses UDP service and another application that uses TCP service. Describe the reason they choose the respective transport service.

(b) **[2 marks]** Why is it necessary for an IP datagram to carry both the source and the destination IP addresses?

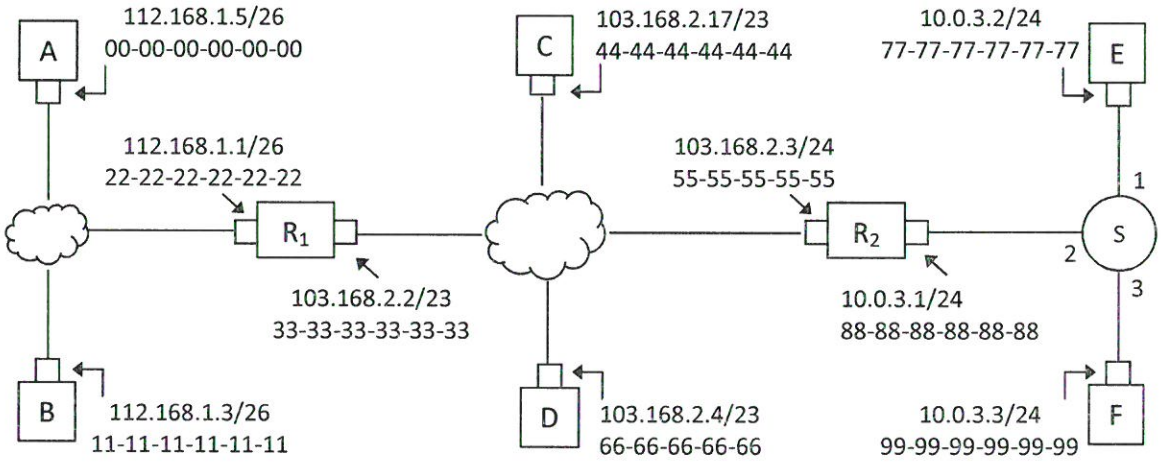
(c) **[3 marks]** To preserve message confidentiality and authenticity, the following information is contained in a secured message sent from Alice to Bob.

- Encrypted hash of the message
- Encrypted message
- Encrypted session key

Briefly describe the purpose of each piece of information and the key used in generating that information.

Q4. **[Total: 12 marks]**

The diagram below shows three LANs interconnected by two routers (R_1 & R_2), with the IP addresses and MAC addresses of various hosts (A...F) and routers given. In particular, R_2 is an NAT-enabled router. S is a switch with 3 interfaces labelled as 1, 2 and 3. Suppose every host and router is aware of the IP address of every other host and router, where applicable.



(a) **[3 marks]** Consider sending an IP datagram from Host E to Host F. Suppose all ARP tables, switch table and forwarding tables are up to date. Outline the main steps and sequence of events/actions required at respective devices (i.e. host/router/switch) to transmit this datagram. Keep your answer accurate and concise.

(b) **[4 marks]** Consider sending an IP datagram from Host F to Host B. Suppose all ARP tables are empty but all other tables are up to date. Outline the main steps and sequence of events/actions required at respective devices to transmit this datagram. Keep your answer accurate and concise.

(c) **[3 marks]** Suppose the switch table of S is initially empty but all the other tables are up to date. The following events happen in sequence:

i. F sends an IP datagram to A

ii. E pings F

iii. A replies with an IP datagram to F

Show the state of the switch table after each of the above events in the format: <MAC address, Interface>. You may ignore TTL field.

Event	Switch table after the event
F sends an IP datagram to A	
E pings F	
A replies with an IP datagram to F	

(d) **[2 marks]** Suppose you are the network administer of the LAN consisting of E, F and R_2. Now you launch a Web server on host E. How can you configure your network so that external hosts such as B and C can access your Web server? Keep your answer succinct.

Q5. **[Total: 9 marks]**

(a) A sliding window protocol is used for transmission. What is the sender utilization given the following parameters of transmission?

i. **[2 marks]** RTT = 24 milliseconds, link rate = 1 Mbps, packet size = 125 bytes, window size = 10

ii. **[2 marks]** RTT = 10 milliseconds, link rate = 100 Mbps, packet size = 1300 bytes, window size = 100

(b) **[2 marks]** To make the TCP initial sequence number a random number, most systems start the counter at 1 during bootstrap and increment the counter by 64,000 every 0.5 s. How long (in seconds) does it take for the counter to wrap around?

(c) **[3 marks]** Is it possible for a TCP sender to receive an ACK for a packet that falls outside of its current send window? Answer "Yes" or "No" and briefly justify your answer.

Q6. **[Total: 9 marks]**

Consider a path from node 0, through nodes 1, 2, ..., till node K+1. The links, from node i to node i+1, for i = 0, 1, ..., K each has the same link rate r bits/s and propagation delay p seconds. Every node, from node 1 through node K, is a store-and-forward device; it begins forwarding a received packet μ seconds after it has finished receiving it.

(a) **[3 marks]** Suppose node 0 sends a message of m bits to node K+1 without message segmentation. What is the end-to-end delay D for transmission (i.e. the duration from when the first bit of the message leaves node 0 to when the last bit of the message arrives at node $K + 1$)?

$D =$

(b) **[4 marks]** Suppose node 0 sends a message of m bits to node K+1 as a series of consecutive packets. Each packet contains h header bits and l data bits. Assume m is divisible by l and $m \gg (h + l)$. What is the end-to-end delay D for transmission (i.e. the duration from when the first bit of the first packet leaves node 0 to when the last bit of the last packet arrives at node $K + 1$)?

$D =$

(c) **[2 marks]** Find the value of l that minimizes the end-to-end delay calculated in (b). (Hint: take the derivative of D w.r.t. l and then set $\frac{dD}{dl} = 0$ to obtain the critical value to minimize D.)

$l =$

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Do **NOT** use it for your rough work.
Use it ONLY if you need extra space for your answer, in which case please indicate the **question number clearly**.

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