NATIONAL UNIVERSITY OF SINGAPORE

CS2105 — INTRODUCTION TO COMPUTER NETWORKS

Semester 1, 2015/2106

Time Allowed: 2 Hours

INSTRUCTIONS TO STUDENTS

1. Please write your Student Number only. Do not write your name.
2. The assessment has one question booklet and one answer booklet.
3. The question booklet contains **FOURTEEN (14) questions** and comprises **ELEVEN (11) pages** including this cover page.
4. The answer booklet contains THREE (3) pages.
5. Weightage of questions is given in square brackets. The maximum attainable score is 50.
6. This is a **CLOSED** book assessment, but you are allowed to bring **ONE (1)** double-sided A4 size, sheet of notes for this exam.
7. The use of electronic calculators is permitted for this assessment.
8. Write all your answers legibly in the **ANSWER BOOKLET**.

Multiple Choice Questions (MCQs) [Total: 16 marks]

Each MCQ has one correct answer and is worth 2 marks. Select the most appropriate answer and **write your answer in the corresponding answer box in the answer sheet**. DO NOT write more than one answer in each box.

1. Which of the following statement about the Internet is FALSE?

   A. The Internet is a network of networks.

   B. E-mail is one of the many services that run over the Internet.

   C. A web browser is used to browse the Internet.

   D. An Internet Service Provider is used to access the Internet.

   E. Documents such as HTML files are stored in servers located throughout the Internet.

2. A baseband channel can transmit a maximum frequency of 1 MHz, and the signal-to-noise ratio is 15. What is the Shannon capacity of the channel?

   A. 1.203 Mbps

   B. 2 Mbps

   C. 3.907 Mbps

   D. 4 Mbps

   E. None of the above

3. An IP address block `192.168.208/20` can be further divided into x subnets, each supporting a maximum of y hosts. Which of the following is NOT a valid assignment.

   A. 4 subnets with 1022 hosts each

   B. 32 subnets with 126 hosts each

   C. 64 subnets with 62 hosts each

   D. 256 subnets with 30 hosts each

   E. 1024 subnets with 2 hosts each

4. Which of the following statements about DNS are true?

   i. If the DNS servers are down, you cannot surf the web but you can still use e-mail.

   ii. DNS maintains the records of hostnames to IP addresses.

   iii. The root servers have to be accessed for every DNS query.

   iv. DNS is an application layer protocol.

   A. (ii) and (iv) only.

   B. (i), (ii) and (iv) only.

   C. (ii), (iii) and (iv) only.

   D. (i), (ii), (iii) and (iv).

   E. (ii) only.

5. Two hosts are communicating using CRC with a generator `101` to detect errors. The first 6 bits of every byte contains the data and the last 2 bits are the CRC value. Which of the following bytes will pass the CRC test and assumed to be without error?

   i. `11010111`

   ii. `10110110`

   iii. `11100110`

   iv. `10001000`

   A. (i) and (ii) only.

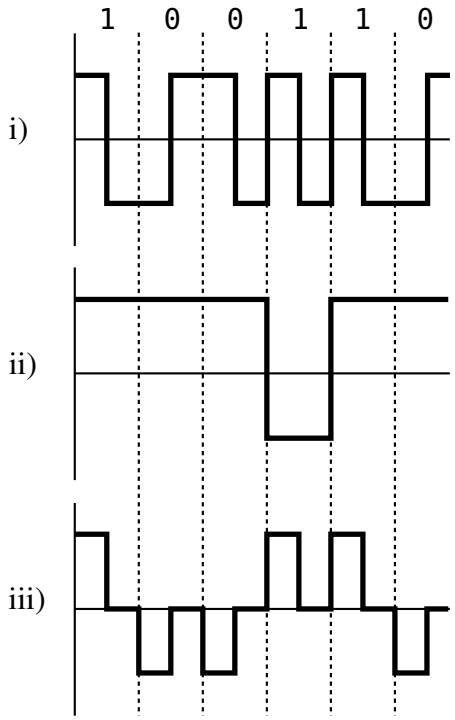
   B. (i) and (iv) only.

   C. (i), (iii) and (iv) only.

   D. (ii) and (iv) only.

   E. (i), (ii) and (iii) only.

6. Which of the following are the corresponding encodings of the signal `100110`?



A. i) Manchester
   ii) NRZ-L
   iii) RZ

B. i) Differential Manchester
   ii) NRZ-L
   iii) NRZ

C. i) Differential Manchester
   ii) NRZ-I
   iii) RZ

D. i) Manchester
   ii) NRZ-I
   iii) RZ

E. i) Manchester
   ii) NRZ-I
   iii) Differential Manchester

7. A router uses longest prefix matching to forward packets and has the following forwarding table:

Prefix	Interface
X	1
Y	2
Z	3

Suppose that a datagram with IP address `010100` was forwarded through interface 1, and a datagram with IP address `011000` was forwarded through interface 2.

Which of the following is NOT a valid set of values for X, Y and Z.

A. X = `01`, Y = `0` and Z = Otherwise

B. X = `01`, Y = Otherwise and Z = `1`

C. X = `01`, Y = `011` and Z = Otherwise

D. X = `010`, Y = `0` and Z = Otherwise

E. X = Otherwise, Y = `011` and Z = `1`

8. Which of the following statements about IP datagram fragmentation is TRUE.

A. An IP datagram is fragmented at the sender when it detects that one of the links in the path has a smaller MTU.

B. A flag = 1 in the IP datagram indicates to the receiver that there is no more outstanding fragments for reassembly.

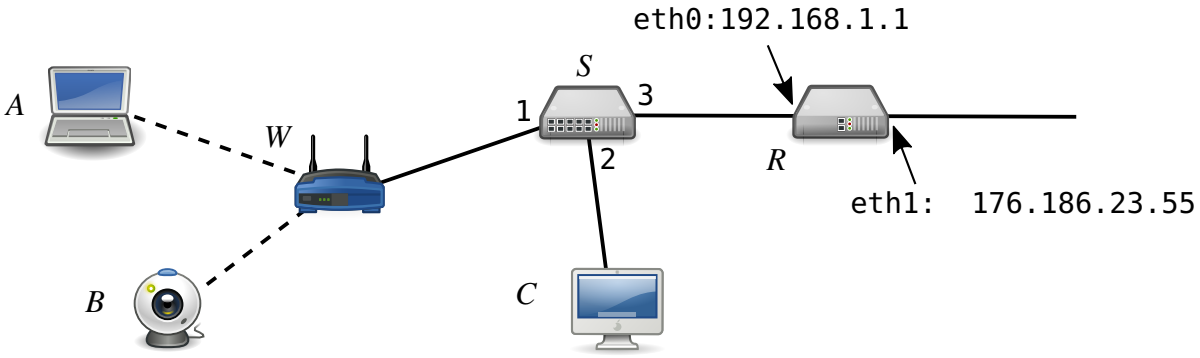
C. The transport layer header of the original datagram is copied to every fragment to ensure correct delivery to the transport layer at the receiver.

D. The header checksum of the original datagram is duplicated to every fragment to ensure errors are correctly detected.

E. The offset field in the header used to align the fragments for reassembly.

Short Answer Questions [Total: 34 marks]

9. [7 marks] The diagram below shows Alice's home network. Hosts *A* and *B* are connected wirelessly to a Wi-Fi access point *W*, which in turn is connected to a switch *S*. Host *C* is directly connected to *S*. *S* is then connected to the network interface `eth0` of router *R*. The network interface `eth1` of *R* is then connected to the Internet via an ISP's modem. The hosts in the network is able to access the Internet via *R*.



(a) [2 marks] Given the IP addresses of *R* as stated in the diagram, suggest valid IP addresses for hosts *A*, *B* and *C* if the subnet mask of the network is `255.255.255.0`.

(b) [2 marks] Suppose the notation MAC_X denotes the MAC address of entity *X* and MAC_{R0} and MAC_{R1} denotes the MAC addresses of *R*'s `eth0` and `eth1` interfaces respectively. Using the output port of the switch as shown in the diagram, list all the possible entries in the switching table of *S*. (e.g., The MAC address of Host *A* is MAC_A, Host *B*'s is MAC_B and so on.)

(c) [3 marks] When using her laptop (*A*) at home, Alice can connect to her IP camera (*B*) using the its IP address and watch the live video stream. But when she brings her laptop to school and connects to the Internet through the school's Wi-Fi network, she can no longer access her IP camera using the same IP address. In fact, sometimes she connects to some stranger's IP camera!

Explain briefly what is the problem and how she can view her camera from school?

10. [6 marks] Alice and Bob wish to establish secure communications over an insecure channel. Because both Alice and Bob have never met each other, they decide to use the Diffie-Hellman protocol to exchange a symmetric key. However, a malicious user Trudy is listening in on their communications and can intercept, delete or inject messages in the channel.

    (a) [3 marks] Describe how Trudy can still eavesdrop on Alice and Bob's secret communication. You may use the analogy of colours presented in class to represent the shared and private secret.

    (b) [3 marks] Suppose Alice and Bob have a common trusted friend Cindy and both Alice and Bob have a secure communication channel with Cindy. How can Cindy help Alice and Bob establish secure communications to exchange their secret love messages?

11. [4 marks] In IEEE 802.11 (Wi-Fi) networks, a sender can adjust the data rate of its transmitted signal. The data rates for 802.11n are represented by a Modulation and Coding Scheme (MCS) index value. The following table shows a sample of the data rates for MCS 0 to 7 with a 20 MHz channel:

MCS index	Modulation type	Coding Rate	Data rate (Mbps)
0	BPSK	1/2	6.5
1	QPSK	1/2	13.0
2	QPSK	3/4	19.5
3	16-QAM	1/2	26.0
4	16-QAM	3/4	39.0
5	64-QAM	1/2	52.0
6	64-QAM	3/4	58.5
7	64-QAM	5/6	65.0
...	...	...	...

    (a) [2 marks] Bob thinks the sender should always use MCS-7 since it gives the highest data rate. Do you agree with Bob? Please explain your answer.

    (b) [2 marks] 802.11n can operate on the 2.4 GHz frequency band as well as the 5 GHz frequency band. Bob thinks that simply switching from the 2.4 GHz frequency band to the 5 GHz frequency band with all other factors being constant, will give him twice the data rate. Do you agree with Bob? Please provide a brief explanation.

12. [6 marks] Alice is attempting to send a file to Bob over the Internet. She has written the following pseudo-code to transfer the bytes of the file using a TCP socket:

```
while (file.hasBytes()) {
    data = file.read(100) // reads 100 bytes to data
    socket.send(data)     // send bytes to socket
}
socket.flush()
socket.close()
```

Bob thinks that there are some issues with her code.

(a) [2 marks] Bob feels that Alice should flush the socket every iteration in the loop. Do you agree with Bob? Explain why.

(b) [2 marks] Alice has a very fast computer while Bob's computer is very slow. He is worried that Alice is sending packets too fast and if he cannot read them fast enough they will be dropped.

Do you think Bob should be worried? If so, how should Alice fix the problem? If not, please explain why.

(c) [2 marks] Bob also thinks that Alice should check that Bob has correctly received every piece of data sent by waiting for him to reply before sending a new piece of data.

Do you agree with Bob? Please explain why.

13. [5 marks] The command "`dig ntu.edu.sg ANY`" was run on `sunfire` and the following output was observed:

```
; <<>> DiG 9.8.1-P1 <<>> ntu.edu.sg ANY
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 15025
;; flags: qr rd ra; QUERY: 1, ANSWER: 8, AUTHORITY: 2, ADDITIONAL: 4

;; QUESTION SECTION:
;ntu.edu.sg.                    IN      ANY

;; ANSWER SECTION:
ntu.edu.sg.             28800   IN      SOA     dnstex.ntu.edu.sg.
                                                servicedesk.ntu.edu.sg.
                                                430592310 1200 180
                                                1209600 3600
ntu.edu.sg.             28800   IN      A       155.69.7.173
ntu.edu.sg.             28800   IN      MX      10 smtp.ntu.edu.sg.
ntu.edu.sg.             28800   IN      MX      10 smtp2.ntu.edu.sg.
ntu.edu.sg.             7200    IN      TXT     "v=spf1 ptr ip4:155.69.5.27
```

```
                                                ip4:155.69.5.28
ntu.edu.sg.             7200    IN      TXT     "google-site-verification=
                                                I-2dOrerQSAAsy2eIa5gHRtit
ntu.edu.sg.             3600    IN      NS      dnstex.ntu.edu.sg.
ntu.edu.sg.             3600    IN      NS      dnstex1.ntu.edu.sg.

;; AUTHORITY SECTION:
ntu.edu.sg.             3600    IN      NS      dnstex1.ntu.edu.sg.
ntu.edu.sg.             3600    IN      NS      dnstex.ntu.edu.sg.

;; ADDITIONAL SECTION:
smtp.ntu.edu.sg.        28800   IN      A       155.69.5.227
smtp2.ntu.edu.sg.       28800   IN      A       155.69.5.52
dnstex.ntu.edu.sg.      3648    IN      A       155.69.254.5
dnstex1.ntu.edu.sg.     3648    IN      A       155.69.254.230

;; Query time: 1 msec
;; SERVER: 137.132.87.2#53(137.132.87.2)
;; WHEN: Mon Nov  23 00:44:29 2015
;; MSG SIZE  rcvd: 686
```

(a) [1 mark] How many local DNS servers are in charge of `ntu.edu.sg`?

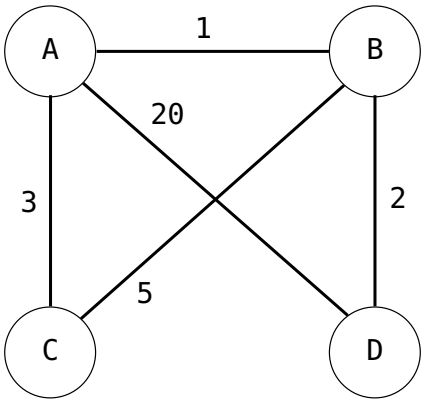
(b) [1 mark] Give the IP address of a local DNS server?

(c) [1 mark] Which DNS server did `dig` obtain the DNS records from?

(d) [1 mark] What IP address will your web browser connect to when you request for `ntu.edu.sg`?

(e) [1 mark] What IP address should an email to `somebody@ntu.edu.sg` be sent to?

14. [6 marks] The following diagram shows a simple topology of 4 nodes with the links labeled with the cost of each link. The nodes run the distance vector routing protocol. The protocol has terminated and each node knows the minimum cost path to every node.



(a) [2 marks] Fill in the routing table for all the nodes.

(b) [2 marks] Suppose the cost of the link between B and D increases from 2 to 30. B detects the change and update its routing table, and sends its vector to A. A then updates its table and sends its vector to C. C then updates its table. Suppose poisoned reverse is used, fill in the new routing tables for nodes A, B and C at this point in time.

(c) [2 marks] Suppose the nodes continue to update each other in the same order. That is B, then A, then C, and back to B and so on, until the protocol terminates. How many times would B have updated its table since the increase in the link cost?

— E N D O F P A P E R —

Scratch Paper

– H A P P Y H O L I D A Y S ! –

Semester 1, 2015/2106 **Answer Sheet** **CS2105 Final Assessment**

Student No: | **S** | **O** | **L** | **U** | **T** | **I** | **O** | **N** | **S** |

Total marks

Write all your answers on this answer sheet. Detach and submit at the end of the assessment.

1:	2:	3:	4:	5:	6:	7:	8:
C	D	D	A	B	C	A	E

9. (a) Host *A*: Any addresses in the range 192.168.1.2 to 192.168.1.254

Host *B*:

Host *C*:

(b)

MAC Address	Output port
MAC_A	1
MAC_B	1
MAC_C	2
MAC_{R0}	3

(c)

Solution: It is because the her IP camera has a private IP address and behind a NAT router. She has to configure port forwarding on the router to the IP camera or use UPNP, and connect to the IP address of the router `176.186.23.55` instead.

10. (a)

Solution: When Alice sends Bob her secret + shared key mixture, Trudy can intercept it and instead send her own secret + shared key mixture to Bob. Similarly, Trudy can also intercept Bob's secret + shared key. Because Alice and Bob has no way of knowing that their original keys have been swapped with Trudy's they each share a symmetric key with Trudy who can read and relay all their messages.

(b)

Solution: Since Alice and Bob have secure communications with Cindy, they can obtain Cindy's public key. Cindy can also sign their public keys with her private key. Alice and Bob can then exchange public keys knowing that they can authenticate them using Cindy's public key. They can then use their private keys to encrypt and send symmetric keys for communication.

11. (a)

Solution: No. Though the data rate is higher, the modulation type is also denser. Thus the transmitted symbols are more susceptible to decoding errors especially in the presence of noise or weak signals. So the actual throughput can be much lower due to corrupted frames.

(b)

Solution: No. The frequency band only dictates the carrier frequency. As the channel bandwidth remains the same, the modulation and data rate will remain the same too.

12. (a)

Solution: No. Because the OS network stack will automatically create and send a packet once there are enough bytes to be sent in the socket. Flushing once at the end is enough to clear the last remaining bytes.

(b)

Solution: No. Because TCP has flow control which prevents the sender from overwhelming the receiver's buffer. This is done automatically by the network stack.

(c)

Solution: No. Because TCP is a reliable delivery protocol. There is no need for the application to check that the data has been received, provided the socket connection is not interrupted.

13. (a)2 (b) `155.69.254.5` or `155.69.254.230` (c)`137.132.87.2` or one from (b)
(d)`155.69.7.173` (e)`155.69.5.52` or `155.69.5.227`

14. (a)

	@A	@B	@C	@D
to A	0	1	3	3
to B	1	0	4	2
to C	3	4	0	6
to D	3	2	6	0

(b)

	@A	@B	@C
to A	0	1	3
to B	1	0	5
to C	3	5	0
to D	12	11	15

(c) 3. B $\rightarrow$ D will be updated from 2 $\rightarrow$ 11 (via A) $\rightarrow$ 20 (via C) $\rightarrow$ 21