

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?

- ☒ The Internet is a network of networks.
- ☒ E-mail is one of the many services that run over the Internet.
- ☒ A web browser is used to browse the Internet.
- ☒ An Internet Service Provider is used to access the Internet.
- ☒ Documents such as HTML files are stored in servers located throughout the Internet.

☒ 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

$$\boxed{192 - 168, 11010000} \cdot \underline{\hspace{2cm}}$$

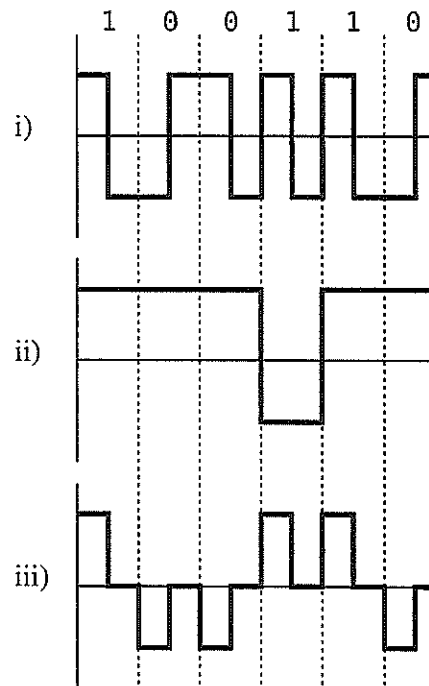
12 bits left

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 1023?
- B. 32 subnets with 126 hosts each 127?
- C. 64 subnets with 62 hosts each 63?
- ☒ D. 256 subnets with 30 hosts each 17?
- E. 1024 subnets with 2 hosts each 2.

4. Which of the following statements about DNS are true? *Can?*
- 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 ÷ 101
 - ii. 10110110 ÷ 101
 - iii. 11100110 ÷ 101
 - iv. 10001000 ÷ 101
- 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.

4. 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

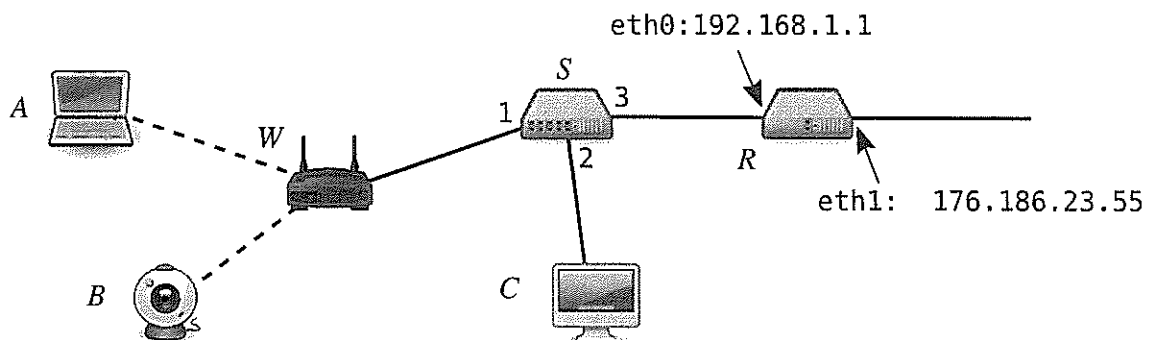
Which of the following is NOT a valid set of values for X, Y and Z.

- A. $X = 01$, $Y = 0$ and $Z = \text{Otherwise}$
 - B. $X = 01$, $Y = \text{Otherwise}$ and $Z = 1$
 - C. $X = 01$, $Y = 011$ and $Z = \text{Otherwise}$
 - D. $X = 010$, $Y = 0$ and $Z = \text{Otherwise}$
 - E. $X = \text{Otherwise}$, $Y = 011$ 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 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.
                             dnstex.ntu.edu.sg.
                             servicedesk.ntu.edu.sg.
```


CS2105 Final Assessment

```

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-2d0rerQSAAsy2eIa5gHRtit
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.

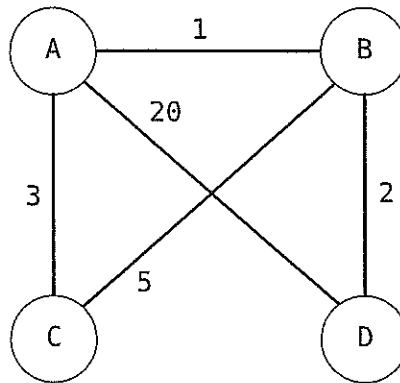
;; ADDITIONAL SECTION:
smtp.ntu.edu.sg.  28800  IN    A    155.69.5.227
smtp2.ntu.edu.sg. 28800  IN    A    155.69.5.52
dnstex.ntu.edu.sg. 3648   IN    A    155.69.254.5
dnstex1.ntu.edu.sg. 3648   IN    A    155.69.254.230

;; 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

```

- [1 mark] How many local DNS servers are in charge of ntu.edu.sg?
- [1 mark] Give the IP address of a local DNS server?
- [1 mark] Which DNS server did dig obtain the DNS records from?
- [1 mark] What IP address will your web browser connect to when you request for ntu.edu.sg?
- [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 ! -