NATIONAL UNIVERSITY OF SINGAPORE

CS2105 – INTRODUCTION TO COMPUTER NETWORKS

(Semester 2: AY2014/2015)

Please DO NOT upload questions and answers onto the Internet.

Time allowed: 2 hours

INSTRUCTIONS TO CANDIDATES

1. This assessment paper contains 7 questions and comprises 10 printed pages, including this page.
2. This is a **CLOSE BOOK** assessment. You are allowed to bring in ONE (1) piece of single-layer, double-sided, A4 size, handwritten reference sheet.
3. The maximum possible score is **60 marks**.
4. Calculators are allowed, but not laptops, PDAs, or other electronic devices.
5. Write all your answers on the **ANSWER SHEET** attached at the back of this paper.
6. Detach the **ANSWER SHEET** for submission at the end of the assessment. You may keep the question paper.
7. Do **NOT** look at the questions until you are told to do so.

Q1. Multiple Choice Questions (MCQs) **[Total: 20 marks]**

Each MCQ has one correct answer and is worth 2 marks.

1.1 Which of the following protocols run at application layer?

i. HTTP
ii. UDP
iii. DHCP
iv. DNS

A. (i) and (iii) only
B. (i) and (iv) only
C. (i), (ii) and (iv) only
D. (i), (iii) and (iv) only
E. None of the above

1.2 1s complement is used as checksum in _____. Given two bytes 01010101 and 11111111, the 1s complement of the sum of them is _____.

A. TCP but not UDP, 10101010
B. UDP but not TCP, 10101010
C. Both TCP and UDP, 10101011
D. Both TCP and UDP, 01010101
E. None of the above

1.3 Which of the following statement about IP datagram is FALSE?

A. Routing protocols determine the routes that datagrams take between sources and destinations.
B. TTL field of IP header prevents a datagram from circulating in the network forever.
C. When a big datagram is fragmented into a series of smaller fragments, transport layer header will be replicated in each fragment.
D. On the Internet, datagrams from the same source may take different routes towards the destination.
E. MTU of the link-layer protocol places a limit on the length of a datagram.

1.4 A channel has bandwidth in the range between 200 KHz - 260 KHz, and a signal to noise ratio of 31. What is the Shannon capacity of the channel?

A. 1.15 Mbps
B. 300 Kbps
C. 1.92 Mbps
D. 1.86 Mbps
E. None of the above

1.5 10 packets are continuously sent over a 1 Mbps link. Each packet is of 1000 bits long and RTT is 10 ms. What is the throughput of the link?

A. 511.856 bps
B. 511.856 Kbps
C. 500 bps
D. 500 Kbps
E. None of the above.

1.6 Void

1.7 If the baud rate for n-PSK signal is 1000 and the bit rate is 5000, what is n?

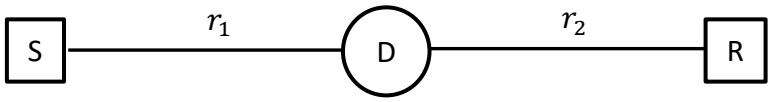
A. 5
B. 4
C. 32
D. 2
E. None of the above

1.8 In a subnet, the first IP address is 172.18.176.0 and the last IP address is 172.18.183.255. What is the length of network prefix of this subnet?

A. 28
B. 29
C. 21
D. 22
E. None of the above

1.9 Void

1.10 A device (D) is used to connect a sender (S) and a receiver (R). Transmission rates of the links between sender and the device and between the device and receiver are r_1 and r_2 ($r_1 > r_2$) respectively. Ignore other types of delay, what is the end-to-end delay to send a packet of length L?



A. $\frac{Lr_1r_2}{r_1+r_2}$, if this device is a store-and-forward packet switch.
B. $\frac{L}{2r_1}+\frac{L}{2r_2}$, if this device is a store-and-forward packet switch.
C. $\frac{L(r_1+r_2)}{r_1r_2}$, if this device acts on individual bits and repeats every bit to receiver once receives it from sender.
D. $\frac{L}{r_1}+\frac{1}{r_2}$, if this device acts on individual bits and repeats every bit to receiver once receives it from sender.
E. $\frac{1}{r_1}+\frac{L}{r_2}$, if this device acts on individual bits and repeats every bit to receiver once receives it from sender.

Q2. **[Total: 3 marks]**

Suppose there is a 10 Mbps microwave link between a geostationary satellite and its base station on Earth, which are 3.6×10^7 meters apart. The satellite takes a digital photo once a while and then sends it to the base station. Assume a propagation speed of 2.4×10^8 meters/second.

(a) [1 mark] What is the propagation delay (in seconds) of the link?

(b) [2 marks] Suppose the satellite takes a photo every 24 seconds and let x denote the size of the photo. What is the minimum value of x (in bits) for the microwave link to be fully utilized (i.e. always busy transmitting)?

Q3. **[Total: 5 marks]**

Consider a datagram network using 8-bit IP addresses. Suppose a router uses longest prefix matching and has the following forwarding table:

Prefix Match	Interface
11	3
101	4
100	1
1101	2
otherwise	0

For each of the five interfaces, give the associated range of destination IP addresses and the number of destination IP addresses in that range.

Q4. **[Total: 6 marks]**

On **`Sunfire`** server, we type the command

```
dig –t a www.duke.edu +trace
```

and observe the following outputs:

```
; <<>> DiG 9.6-ESV-R8 <<>> www.duke.edu +trace
;; global options: +cmd
.                  155852  IN      NS      b.root-servers.net.
.                  155852  IN      NS      c.root-servers.net.
.                  155852  IN      NS      d.root-servers.net.
.                  155852  IN      NS      e.root-servers.net.
.                  155852  IN      NS      f.root-servers.net.
.                  155852  IN      NS      g.root-servers.net.
.                  155852  IN      NS      h.root-servers.net.
.                  155852  IN      NS      i.root-servers.net.
.                  155852  IN      NS      j.root-servers.net.
.                  155852  IN      NS      k.root-servers.net.
.                  155852  IN      NS      l.root-servers.net.
.                  155852  IN      NS      m.root-servers.net.
.                  155852  IN      NS      a.root-servers.net.
;; Received 492 bytes from 137.132.85.2#53(137.132.85.2) in 13 ms

edu.               172800  IN      NS      a.edu-servers.net.
edu.               172800  IN      NS      f.edu-servers.net.
edu.               172800  IN      NS      d.edu-servers.net.
edu.               172800  IN      NS      c.edu-servers.net.
edu.               172800  IN      NS      g.edu-servers.net.
edu.               172800  IN      NS      l.edu-servers.net.
;; Received 265 bytes from 192.33.4.12#53(192.33.4.12) in 182 ms

duke.edu.          172800  IN      NS      avallone.stanford.edu.
duke.edu.          172800  IN      NS      dns-auth-01.oit.duke.edu.
duke.edu.          172800  IN      NS      dns-auth-02.oit.duke.edu.
;; Received 194 bytes from 192.31.80.30#53(192.31.80.30) in 259 ms
```

```
www.duke.edu.       21600   IN      CNAME   duke.edu.
duke.edu.           21600   IN      A       54.191.241.8
duke.edu.           21600   IN      A       54.68.155.51
duke.edu.           21600   IN      NS      dns-auth-02.oit.duke.edu.
duke.edu.           21600   IN      NS      dns-auth-01.oit.duke.edu.
;; Received 164 bytes from 152.3.105.232#53(152.3.105.232) in 270 ms
```

Answer the following questions.

(a) [1 mark] Write down one IP address of a local DNS server

(b) [1 mark] Write down one IP address of a root DNS server

(c) [1 mark] Write down one IP address of a top-level domain DNS server

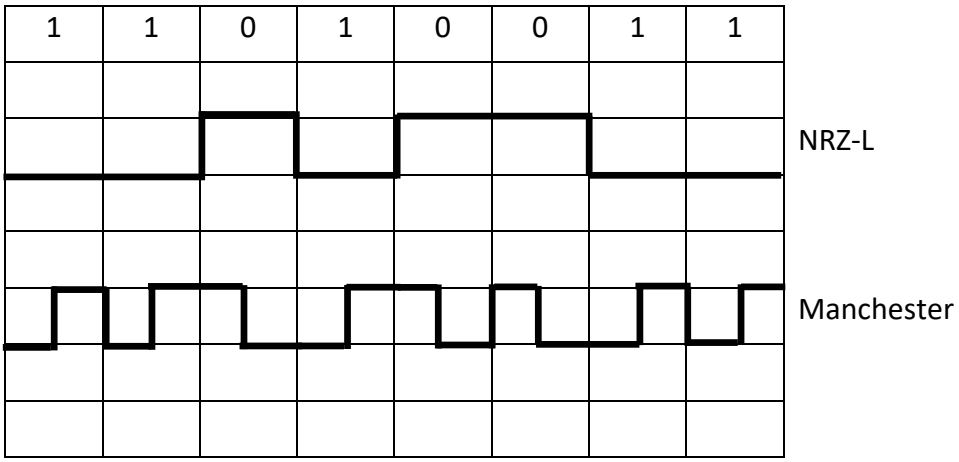
(d) [1 mark] Write down one IP address of `www.duke.edu`

(e) [1 mark] What is the canonical name of `www.duke.edu`?

(f) [1 mark] What port number does a DNS server listen to?

Q5. **[Total: 8 marks]**

(a) [1 mark] The correct drawing of NRZ-L for bit pattern 11010011 is shown in the grid below. Is corresponding Manchester encoding correctly drawn? Answer "Yes" or "No".



(b) [3 marks] Suppose the propagation delay between furthest nodes is d and link rate is r. What is the minimal frame size L to ensure collision will always be detected in CSMA/CD protocol?

(c) [4 marks] Source and destination are connected by a single link that has packet loss probability of p. If at most k (re)transmissions are allowed until the source gives up, what is the probability that a packet would be successfully delivered to destination?

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

Host A sends 5 data packets to host B using TCP protocol. Each data packet contains 10 bytes of application data.

Answer the following 3 questions. They are independent of each other.

(a) [3 marks] Suppose 5 data packets arrive in order and all are accepted by B. The last ACK packet sent by B has ACK number 99. What is the sequence number of the first data packet sent by A?

(b) [3 marks] Suppose 5 data packets arrive at B out of order. Their sequence numbers (shown in the order of arrival) are 200, 240, 210, 230 and 220 respectively. Assume B will buffer out-of-order packets for later in-order delivery to application. Write down ACK numbers of the corresponding ACK packets sent by B.

(c) [3 marks] Within 100 ms duration, B receives 5 in-order data packets and accepts all of them. How many ACK packets will B send out?

Q7. **[Total: 9 marks]**

10 students want to communicate with each other confidentially (i.e., messages between any two students shouldn't be understandable to a third student).

Answer the following 3 questions. They are independent of each other.

(a) [2 marks] In symmetric key cryptography, how many secret keys are needed in total?

(b) [3 marks] Suppose every student trusts the teacher. If a student needs to send a message to another, he first sends it to the teacher; the teacher then sends the message to the other student. The teacher is allowed to understand all messages sent to her. At a minimum how many keys are needed in total? State clearly if symmetric or public key cryptography is used.

(c) [4 marks] Suppose every student has a pair of public/private keys, so does the teacher. Now the teacher has a short announcement for all the students. In no more than 80 words, write down the steps the teacher performs to ensure confidentiality and authenticity of this announcement.

=== END OF PAPER ===

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

(Write down your student number legibly using a **PEN**)

TOTAL MARKS

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

1.1	**D**	**1.2**	**E**	**1.3**	**C**	**1.4**	**B**	**1.5**	**E**
1.6		**1.7**	**C**	**1.8**	**C**	**1.9**		**1.10**	**E**

2.

(a)	(b)
0.15 s	$2.4 * 10^8$ b

3.

Interface	IP Range	No. of IP
3	1100 0000 – 1100 1111 1110 0000 – 1111 1111	32+16=48
4	1010 0000 – 1011 1111	32
1	1000 0000 – 1001 1111	32
2	1101 0000 – 1101 1111	16
0	0000 0000 – 0111 1111	128

4.

(a)	(b)
137.132.85.2	192.33.4.12

4.

(c)	(d)
192.31.80.30	54.191.241.8
(e)	**(f)**
duke.edu	53

5.

(a)	(b)
Yes	2 * d * r
(c)	
(1- p) + p * (1-p) + p^2 * (1- p) + … + p^{k-1} * (1- p)	

6.

(a)	(b)
49	210, 210, 220, 220, 250
(c)	
3	

7.

(a)	(b)
45	10 (symmetric key cryptography)
(c)	
Any reasonable answer will be accepted. State your assumptions clearly.	

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