NATIONAL UNIVERSITY OF SINGAPORE

CS2105 – INTRODUCTION TO COMPUTER NETWORKS

Mock Exam Paper 1

Please DO NOT upload questions and answers onto the Internet.

Time allowed: 2 hours

INSTRUCTIONS TO CANDIDATES

1. This assessment paper contains **SEVEN** questions and comprises **SIX** printed pages, including this page.
2. This is an **OPEN BOOK** assessment.
3. Calculators are allowed, but not laptops, PDAs, or other electronic devices.
4. There is no need to show your working for each question.

Q1. Multiple Choice Questions (MCQs)

1.1 Which of the following protocols run at the transport layer?

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

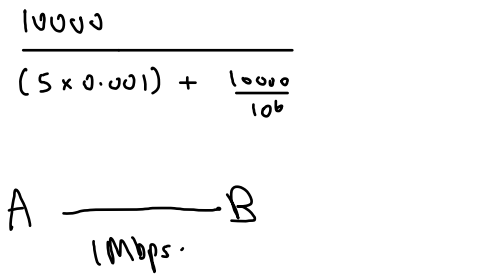
A. (i) and (iii) only
B. (ii) only
C. (ii) and (iii) only
D. (i), (iii) and (iv) only
E. None of the above

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

A. both TCP and UDP but not IP, 10101010
B. both TCP and UDP but not IP, 01010101
C. IP only but not TCP or UDP, 01010101
D. TCP, UDP and IP, 10101010
E. None of the above

1.3 10 packets are continuously sent over a 1 Mbps link. Each packet is of 1,000 bits long and RTT is 10 ms. What is the throughput of the link (i.e. on average, how many bits transmitted per second)?

A. 511.856 bps
B. 511.856 Kbps
C. 500 bps
D. 500 Kbps
E. 666.667 Kbps



1.4 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

1.5 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.

1.6 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

128 64 32 16 8 4 2 1

1 0 1 1 0 0 0 0

1 0 1 1 0 1 1 1

1.7 A host uses a variety of protocols to discover information about the network it is connected to. Which of the following statements is FALSE?

A. To perform a DNS lookup, a host must first discover the IP address of its local DNS server using DHCP.

B. To send a packet outside the host's subnet, the host must first discover the IP address of its first-hop router using DHCP.

C. To send a packet outside the host's subnet, a host must first discover the IP address of the destination host using DNS. ? True.

D. To get an IP address assigned, a host must first discover the IP address of its DHCP server using DNS. broadcast either. → no need to know.

E. To send a packet to another host in the same subnet, a host must first discover the MAC address of the destination host using ARP.

1.8 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. x = 4 and y = 1022

B. x = 32 and y = 126

C. x = 64 and y = 62

D. x = 256 and y = 30

E. x = 1024 and y = 2

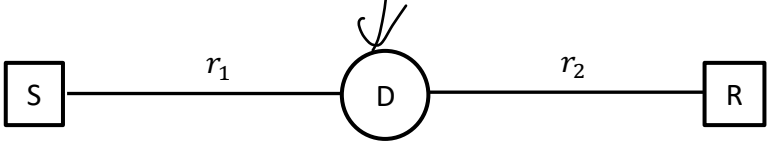
128 64 32 16 8 4 2 1 x x x x x x x x

1 1 0 1 0 0 0 0

1.9 Given the CRC generator **1001**, which of the following bit sequence received by receiver is not corrupted?

A. **11000010**
B. **11000111**
C. **11000110**
D. **11000011**
E. **11000001**

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.

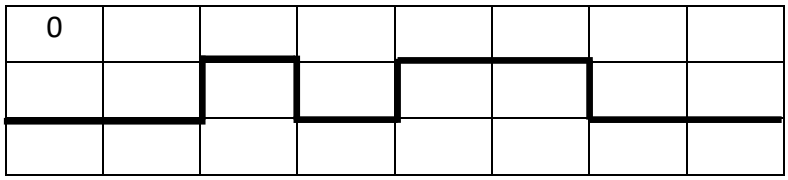
Suppose there is a 10 Mbps microwave link between a geostationary satellite and its base station on Earth, which are 3.6×10^7 meters apart. The satellite takes a digital photo once in a while and then sends it to the base station. Assume a propagation speed of 2.4×10^8 meters/second.

(a) What is the propagation delay (in seconds) of the link?

(b) 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. the satellite always busy transmitting)?

Q3.

(a) What bit pattern does the following NRZ-I diagram represent? Suppose the first bit is 0.



(b) 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?

(c) 1.8 Mb of data is transmitted in 60 seconds using 8-PSK. What is the baud rate of the signal?

(d) 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?

Q4.

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.

Q5. similar to mcq q10.

Two hosts A and B are connected via a router. The link rate is 1 Mbps and propagation delay is 40 ms per link. The maximum size of a packet is 1 Kb and packet header is 80 bits. Suppose sender sends as much data as possible in a packet, packets are sent continuously and no packet is corrupted or lost during transmission.

How long (in milliseconds) does it take to send a 400 Kb file from A to B (from when the first bit of the first packet leaves A to when last bit of the last packet arrives at B)?

Q6.

Public key cryptography uses both public and private keys. Let Alice's public key be K_A^+ and private key be K_A^-, Bob's public key be K_B^+ and private key be K_B^-. Alice sends a message m to Bob. Describe how they can ensure message confidentiality and integrity using only these 4 keys.

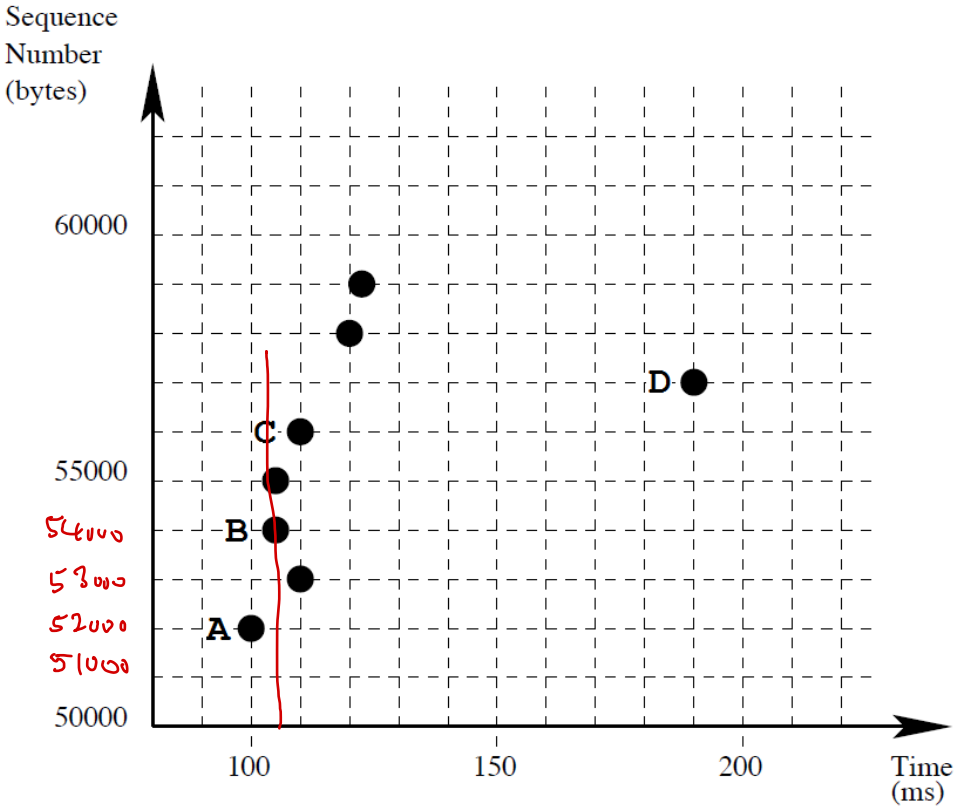
literally draw out the steps.

Confidentiality: encrypt m with K_A^+, decrypt with K_A^-

Integrity: send $(m, K_B^-(H(m)))$, decrypt with K_B^+, verify the hash is correct.

Q7.

The following graph shows the time sequence graph for a TCP connection between host X and host Y. Each dot represents a TCP segment received at host Y, plotting the sequence number of the segment, versus the time at which it is received. A set of dots stacked above each other represents a series of packets that are received back-to-back by the receiver. The packet labelled with A is the first data packet sent by X. The packet labelled with D is a re-transmitted packet.



(a) How many bytes of data are there in each TCP segment? 1000

(b) Suppose an acknowledgment is sent by Y at time 105ms, after receiving the packet labelled with B. What should be the acknowledgement number in this feedback packet? ~~55000~~ 53000

(c) Does Y buffer out-of-order packets or discard them? Justify your answer in no more than 100 words. Buffer. B is out of order but not transmitted.

=== END OF PAPER ===

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

2.

(a) **$3.6*10^7 / 2.4*10^8 = 0.15$**

(b) **x / 10Mbps = 24; $x = 2.4 * 10^8$**

3.

(a) **00111010**

(b) **300 Kbps**

(c) $\frac{1.8* 10^6}{60*3} = 10,000$

(d) **$2 * d * r$**

(Draw timeline diagram. Consider the worst case that *A* sends a frame to *B*. Just before this frame reaches B, B starts transmission. It takes *A* around RTT to receive the first bit from *B* and thus detect collision.)

4.

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

5.

# of pkt = $\left\lceil \frac{400 * 10^3}{1000-80} \right\rceil = 435$

Total # of bits sent = 435*80 + 400,000 = 434,800

Length of first 434 packets: 1,000

Length of last packet: 800

End-to-end delay = $\frac{1000}{10^3} + 40 + \frac{434{,}800}{10^3} + 40 = 515.8$ **ms**

6.

1. **Alice encrypts** m **with her private key to create digital signature** $K_A^-(m)$.
2. **Alice concatenates message with digital signature** $m \oplus K_A^-(m)$, **and encrypt the extended message with Bob's public key:** $K_B^+(m \oplus K_A^-(m))$.
3. **Alice sends** $K_B^+(m \oplus K_A^-(m))$ **to Bob.**
4. **Bob decrypts the received message using his private key:** $K_B^-(K_B^+(m \oplus K_A^-(m))) = m \oplus K_A^-(m)$.
5. **Bob then uses Alice's public key to derive message from digital signature:** $K_A^+(K_A^-(m)) = m'$
6. **If** $m = m'$, **message integrity is preserved.**
7. **Because message is encrypted during transmission, message confidentiality is preserved.**

(Another approach is for Alice to send $K_B^+(m) \oplus K_A^-(K_B^+(m))$**)**

7.

(a) **1,000**

(b) **53,000**

(c) **Y buffers out-of-order packets. The packet B is an out-of-order packet. However, it is not retransmitted even if a later packet D is already retransmitted. That implies 53,000 is buffered and already acknowledged.**