NATIONAL UNIVERSITY OF SINGAPORE

SCHOOL OF COMPUTING

END-OF-MODULE ASSESSMENT FOR
Special Term II AY2016/2017

CS2105 - INTRODUCTION TO COMPUTER NETWORKS

July 2017 Time Allowed: 2 Hours

INSTRUCTIONS TO CANDIDATES

1. This assessment paper contains **THREE (3)** questions and comprises **FOURTEEN (14)** printed pages, including this page and a work page for your rough work.
2. Answer **ALL** questions in the space provided in the assessment paper.
3. This is a *CLOSED BOOK* assessment. Electronic gadgets other than approved calculators are not allowed.
4. Please write your Student Number below.

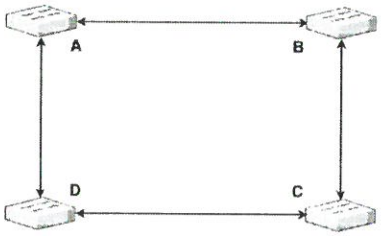
STUDENT NO: _____

This portion is for evaluator's use only

Question	Max Marks	Marks	Remarks
Q-A	36		
Q-B	20		
Q-C	44		
Total	100		

<Page for your rough work>

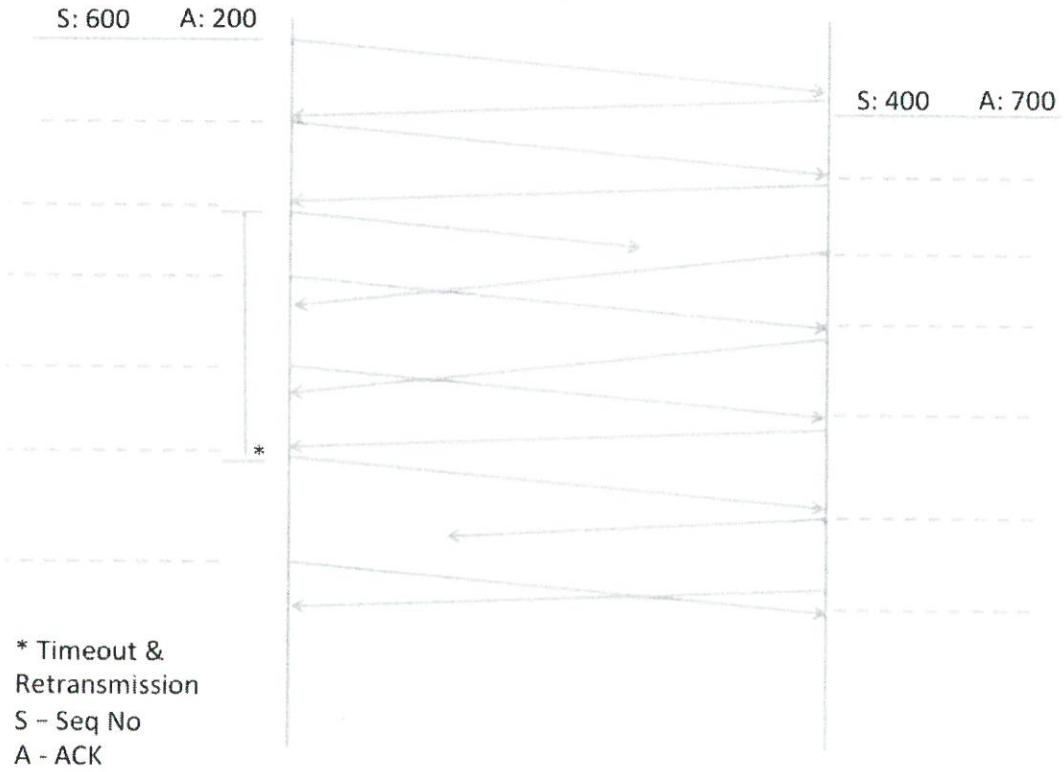
A.	**Introduction, application layer & security [36 marks]**	Mark
1.	Study the output of *dig* and *host* commands and answer the following questions. ; <<>> DiG 9.8.3-P1 <<>> www.comp.nus.edu.sg +trace ;; global options: +cmd . 184094 IN NS f.root-servers.net. . 184094 IN NS j.root-servers.net. . 184094 IN NS i.root-servers.net. . 184094 IN NS e.root-servers.net. . 184094 IN NS c.root-servers.net. . 184094 IN NS k.root-servers.net. . 184094 IN NS d.root-servers.net. . 184094 IN NS l.root-servers.net. . 184094 IN NS b.root-servers.net. . 184094 IN NS a.root-servers.net. . 184094 IN NS h.root-servers.net. . 184094 IN NS m.root-servers.net. . 184094 IN NS g.root-servers.net. ;; Received 256 bytes from 192.168.0.1#53(192.168.0.1) in 39 ms sg. 172800 IN NS sec3.apnic.net. sg. 172800 IN NS dsany2.sgnic.sg. sg. 172800 IN NS ns2.cuhk.edu.hk. sg. 172800 IN NS sg-ns.anycast.pch.net. sg. 172800 IN NS dsany.sgnic.sg. ;; Received 393 bytes from 192.228.79.201#53(192.228.79.201) in 518 ms nus.edu.sg. 3600 IN NS ns2.nus.edu.sg. nus.edu.sg. 3600 IN NS dnssec2.singnet.com.sg. nus.edu.sg. 3600 IN NS dnssec3.singnet.com.sg. nus.edu.sg. 3600 IN NS ns1.nus.edu.sg. nus.edu.sg. 3600 IN NS dnssec1.singnet.com.sg. ;; Received 183 bytes from 204.61.216.57#53(204.61.216.57) in 62 ms comp.nus.edu.sg. 86400 IN NS ns2.comp.nus.edu.sg. comp.nus.edu.sg. 86400 IN NS ns3.comp.nus.edu.sg. comp.nus.edu.sg. 86400 IN NS ns1.comp.nus.edu.sg. comp.nus.edu.sg. 86400 IN NS ns2.nus.edu.sg. comp.nus.edu.sg. 86400 IN NS ns1.nus.edu.sg. ;; Received 207 bytes from 165.21.100.11#53(165.21.100.11) in 92 ms www.comp.nus.edu.sg. 86400 IN CNAME www0.comp.nus.edu.sg. www0.comp.nus.edu.sg. 86400 IN A 137.132.80.57 comp.nus.edu.sg. 86400 IN NS ns1.comp.nus.edu.sg. comp.nus.edu.sg. 86400 IN NS ns2.nus.edu.sg. comp.nus.edu.sg. 86400 IN NS ns2.comp.nus.edu.sg. comp.nus.edu.sg. 86400 IN NS ns3.comp.nus.edu.sg. comp.nus.edu.sg. 86400 IN NS ns1.nus.edu.sg. ;; Received 242 bytes from d#53(137.132.5.2) in 41 ms BadduBlueMountain:~ host 204.61.216.57 57.216.61.204.in-addr.arpa domain name pointer sg-ns.anycast.pch.net.	
(a)	Which DNS servers were queried?	(2)

(b)	Write IP address of the local DNS server?	(2)
(c)	Write IP address of an authoritative name server?	(2)
(d)	Based on the resource records (references) returned by the server `sg-ns.anycast.pch.net.` and the subsequent queries, state which name servers could have got the next query? State domain names.	(2)
2.	Four switches, A,B,C and D are connected as shown in the diagram below forming a circuit switched network. Each link is divided into eight channels/bands with FDM to support simultaneous transmissions.	
(a)	Suppose 20 nodes in B want to communicate with 20 nodes in D simultaneously. Assume no other communications in the network. Is it possible to support 20 simultaneous connections/circuits between B and D? How many simultaneous circuits can be established between B and D.	(3)
(b)	Suppose 8 nodes in A wants to communicate with 8 nodes in C, and 8 nodes in B wants to communicate with 8 nodes in D simultaneously. Assume no other communications in the network. Is it possible to establish all 16 circuits to support this request? How? 	(3)

3. (a)	Suppose TA Lim wants to send the graded assignment marks to Professor. Lim is worried that some students may have hacked a router along the path and might modify the message to improve their marks. Lim creates a Hash of the message (containing marks) and transmit both message (M) and Hash (H(M)) to Professor. Professor creates H'(M) and accepts the message if H = H'. Does this procdure ensure integrity of the message? (Note: You can assume that Hash is a secure hash function that is one-way, collision resistant, and pre-image resistant.)	(4)
(b)	Suppose TA Lim wants to send the marks confidentially to the Professor, as the marks are not supposed to be revealed to the students. Professor computes grades based on marks and publishes only the grades to students. So Lim encrypts the message using his private key and sends it to the Professor. The professor decrypts the message using Lim's public key.	
(b)(i)	Does the procedure ensure confidentiality of the message?	(3)
(b)(ii)	Does the procedure ensure integrity of the message?	(3)
(b)(iii)	Does the procedure help the Professor to authenticate the sender (Lim)?	(3)

4.	User X and user Y have established shared key with KDC A and KDC B respectively. KDC A and KDC B have established shared key KDC C. Develop a method (protocol) to enable a user X from KDC A to obtain a shared key to communicate with a user Y from KDC B. KDCs A, B and C must participate in the process of establishing the shared key K_{XY} between User X and User Y.	(9)
	(36 marks)	

B.	**Reliable transport protocols and transport layer [20 marks]**	Mark
1.	Assume a 10 Mbps channel with 200ms propagation delay and an average of 5% transmission errors (loss and bit error). Assume that the sliding window protocols over this channel use a *3-bit* sequence number. Which of the two sliding window protocols (Go-Back-N and Selective Repeat) would you expect to have better performance across the channel when 100 packets of size 60 KB are transferred? Explain.	(4)
2.	Suppose that we attempt to run the SR algorithm with *window size 6* and with *highest sequence number 7* (Note:- sequence numbers start from 0). The *n-th packet* thus actually contains *n mod 8* in its sequence number field. Give an example in which the receiver expects 8^{th} *frame* and accepts 0^{th} *frame* (which is a duplicate frame). No packets may arrive out of order. What should be the maximum window size for the protocol to function correctly?	(6)

3.	TCP Tahoe receiver buffers out of order packets like Selective Repeat protocol. However, TCP differs from SR by using cumulative acknowledgement instead of acknowledging the segments individually. What are the disadvantages of using cumulative acknowledgement?	(4)
4.	Consider the following TCP communication between Host X and Host Y (shown in the diagram). Both hosts send data to each other. Hosts send an acknowledgement whenever they receive a segment (NO delayed ACK). Host Y has already received from host X all bytes up to byte 599. Host X has already received from host Y all bytes up to byte 199. Host A then sends **SIX** more segments of size **100** bytes to Host B. Host B then sends **SEVEN** more segments of size **200** bytes to Host A. Complete the sequence numbers and acknowledgement numbers of all the segments in the diagram. 	(6)
	(20 marks)	

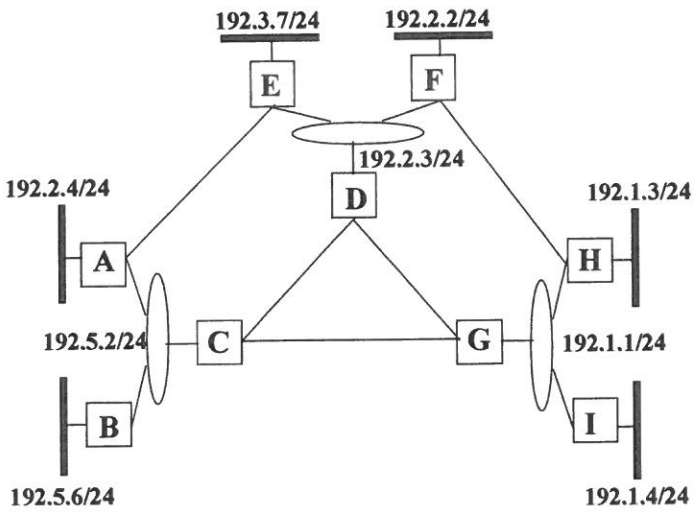
C.	**Network layer and link layer [44 marks]**	Mark
1.	Your are hired as a consultant to a company to redesign its network. The company has the following requirements. • The company has a 10Gbps high speed backbone Ethernet comprising 6 servers and with potential to expand up to 10 servers. • The backbone network is connected to 2 other clusters through routers. One serving R&D department, which has 7 labs at present, with potential to expand up to 12 labs. Each lab requires at least 60 IP addresses. • The other cluster is providing access to both on-site and remote sales personnel. The number of on-site sales people is 20 and expandable to 30 in the foreseeable future. Each on-site sale person has a desktop computer. • The remote sales people access the network via VPN, and at any given time it is expected that not more than 10 people access the network. • For security reasons the company does not want to use any NAT box. For these requirements,	
(a)	Suggest a cost effective size of the public IP address block required.	(2)

(b) Draw a neat diagram of the network. (6)

(c) For each LAN (or lab), provide the IP subnet details such as net-id, broadcast-id and netmask in the format shown in the table below. Assume the starting block address of the network as 140.80.0.0/n where "n" is the number you have determined from part (a). (8)

Network Name	Net-id (a.b.c.d/n)	Broadcast id
Backbone		
Lab-1		
Lab-2		
Lab-3		
Lab-4		
Lab-5		
Lab-6		
Lab-7		
On-site sales persons network		
Remote sales persons network		
Unused blocks (list all in multiple rows)		

2. Study the following network where all the routers use distance vector protocol with hop count as cost. Assume that at time T1, the interface on router I to 192.1.4/24 has just failed and router I marks 16 (considered ∞ in RIP). Also assume that at times T1, T2 , …etc., all the nine routers A-I send routing updates simultaneously to their neighbours. Fill in the columns in the following table with the routing table entry of routers A-I at times T2, T3 , and T4 for 192.1.4/24 . Show each entry as a (hop count, next-hop) pair. Has the protocol converged at T4 ? When it will converge? (6)



Routers → Time	A	B	C	D	E	F	G	H	I
T1	4,C	4,C	3,G	3,G	4,D	3,H	2,I	2,I	∞
T2									
T3									
T4									
T5									
T6									
T7									
T8									
T9									
T10									
T11									
T12									
T13									
T14									
T15									

3.	Packets of 2000 bits are sent over a 100 kbps channel from node A to node B. The propagation delay from node A to node B is 500 msec.	
(a)	What is the channel utilization if stop-and-wait protocol is used?	(2)
(b)	If sliding window protocol is used to improve the channel utilization, find an appropriate choice of the window size, so that the sender will be able to continuously transmit packets.	(5)
4.	Ten thousand wireless stations are competing for the use of a single slotted-ALOHA channel. On an average each station makes 18 requests/hour. A slot (frame transmission time) is 125 microseconds. What is the channel load (G)?	(4)

5.	Assume there are only two stations, A and B, in a bus CSMA/CD network. The distance between the two stations is 2000 m and the propagation speed is $2x10^8$ m/s. The frame transmission time is 100 μs. If station A starts transmitting at time t_1:	
(a)	Does the protocol allow station B to start transmitting at time t_1+ 7 μs?	(2)
(b)	Does the protocol allow station B to start transmitting at time t_1+ 11 μs?	(2)
(c)	Does the protocol allow station B to start transmitting at time t_1+111 μs?	(2)

6.	Given the dataword 1110011010 and the divisor 10111. Show the generation of the CRC codeword at the sender site. (Show binary division operation.)	(5)
	(44 marks)	

---------- END OF PAPER ----------