NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF COMPUTING AND INFORMATICS

DEPARTMENT OF COMPUTER SCIENCE

QUALIFICATION: BACHELOR OF COMPUTER SCIENCE HONOURS : COMMUNICATION NETWORKS	
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FIRST OPPORTUNITY EXAMINATION QUESTION PAPER	
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INSTRUCTIONS

1. Answer ALL the questions.
2. Write clearly and neatly.
3. Number the answers clearly.

THIS QUESTION PAPER CONSISTS OF 9 PAGES (Including this front page)

Question 1 [18 marks]		
a)	In TCP flow control, what is the relationship between segment sequence numbers and acknowledgement numbers? Use a random sequence number for your answer.	4 Marks
b)	Many Internet companies today provide streaming video, including YouTube, Netflix, and Hulu. Name any two distinguished features that characterize streaming stored video?	2 Marks
c)	List two advantages of using optical fiber in contrast to the conventional copper cable links.	2 Marks
d)	What are the two advantages of using small, fixed-length cells in ATM	2 Marks
e)	Explain the main difference between ADSL and VDSL used for broadband communication. Which of these two technologies give better performance in terms of speed?	3 Marks
f)	Why is round time an appropriate timescale for frame retransmission?	3 marks
g)	Name two factors that can cause variance in the network round-trip time	2 marks

Question 2 [16 marks]

Consider two hosts A and B that communicate via a router R. The link (A, R) has infinite bandwidth: packets experience no delay on this link. The link (R, B) has finite bandwidth: the packet transmission rate on the link (R,B) is 1 packet per second. However, acknowledgements from B to R are sent instantaneously, as are ACKs from R to A. Host A sends data to host B over a TCP connection using slow start but with an arbitrarily large window size. Router R has a queue size of 1 packet in addition to the packet that router R is transmitting on the outbound link (R, B). Consider the timeline illustrated in Figure 1. Time advances in units of 1 second. At each second the sender first processes any arriving ACKs and then responds to any timeouts. Assume that the timeout period T is 2 seconds. Figure 1 shows the items sent and received during the period T = 1, 2. . . 7 seconds.

Note that in Figure 1, it is assumed that when TCP encounters a timeout it reverts to stop-and-wait as the outstanding lost packets in the existing window are re-transmitted one at a time, and that the slow start phase will begin again only when the existing window is fully acknowledged. Note also that once a timeout and re-transmission is pending, subsequent timeouts of later packets are ignored until their earlier acknowledgment is received. Answer the following questions concerning the timeline illustrated in Figure 1.

Time T	A receives	A sends	R sends	cwnd
0		data0 (slow start)	data0	1
1	ack0	data1, data2	data1	2
2	ack1	data3, data4 (data4 dropped)	data2	3
3	ack2	data5, data6 (data6 dropped)	data3	4
4	ack3 (timeout data4)	data4	data5	1
5	ack3 (timeout data5, data6)		data4	1
6	ack5	data6	data6	1
7	ack6	data7, data8 (slow start)	data7	2

Figure 1. TCP Timeline

a)	At time T = 2: why is packet data4 dropped?	**2 Marks**
b)	At time T = 2: why are only 2 packets data3 and data4 sent even though cwnd=3?	**2 Marks**
c)	At time T = 3: why are only 2 packets data5 and data6 sent even though cwnd=4?	**2 Marks**
d)	At time T = 3: why is data6 dropped?	**2 Marks**
e)	At time T = 4: why does a timeout occur?	**2 Marks**
f)	At time T = 5: why does A receive ack3 even though data5 was received at B at the previous step?	**2 Marks**
g)	At time T = 5: why do 2 timeouts occur?	**2 Marks**
h)	At time T = 6: why does A receive ack5 even though data4 was received at B at the previous step?	**2 Marks**

Question 3 [8 marks]

Suppose that a router has three input flows and one output port. It receives packets continuously as per Table 1, with all flows beginning at the same time and queues being empty before the arrival of the first packet. Packet order in each separate flow is listed in the table (packets 1, 5 and 7 are the first to arrive). Length represents the number of clock ticks it takes to transmit a packet.

Table 1. Router Input Flows

Packet id	Length	Flow
1	100	1
2	110	1
3	50	1
4	160	2
5	80	2
6	240	2
7	90	3
8	180	3

a)	Fair queuing is used.	**4 Marks**
b)	Weighted fair queuing with flow 2 having twice as much share as flow 1, and flow 3 having 1.5 times as much share as flow 1.	**4 Marks**

Question 4 [6 marks]

One difficulty with the round-trip time estimator (sRTT) in TCP is the choice of an initial value. If the absence of any special knowledge of network conditions, the typical approach is to pick an arbitrary value, and hope that this will converge quickly to an accurate value. Assume there is no loss of segments in the network, and that the initial value of sRTT is 100.75 ms, the first acknowledgment for the TCP connection have been returned with RTT for the first ACK =120 ms with an estimated standard deviation measurement of 5.06. Determine the value of the timeout after the acknowledgments using RFC 793 formula with α = 0.175 and y =0.25 for the standard deviation

Question 5 [8 marks]		
a)	Consider 10 flows passing through a Fair Queue (FQ) router with an outgoing link running at 100Mbps. Five of the flows are part of a file backup service and can each fill the link if they are allowed to. The other five are video streams running at 2Mbps. Given that the router is the bottleneck for all the flows, how fast do the flows operate?	**4 Marks**
b)	Assume a link of capacity 10 Mbps that is traversed by four flows with arrival rates of 6, 4, 2, and 1 Mbps, respectively. What bandwidth will each flow get? (Show all your work.)	**4 Marks**

Question 6 [12 marks]

Consider the IP network shown in Figure 2. Routers R1 to R6 belong to a network using MPLS (R1 to R6 are LSRs). These routers connect networks A, B, C and D. The topology links, whether internal to the MPLS network or external, have a capacity of 1 Gb/s. We are interested in communications to C and D and have the following information: R1 has announced to R2 and R3 that it can route packets but only to network D; R2 has announced to R4 that it can route packets to Network C and Network D; R3 has announced to R4 that it can route packets to Network D; R4 has announced to R5 and R6 that it can route packets to C and D. We know the routing tables of routers R1 to R6.

R1 Routing Table		
Dest.	NH	Cost
R1	-	-
R2	R2	10
R3	R3	10
R4	R2	10
R5	R2	10
R6	R2	10
A	R2	10
B	R2	10
C	R2	10
D	D	10
Default	R2	10

R2 Routing Table		
Dest.	NH	Cost
R1	R1	10
R2	-	-
R3	R4	20
R4	R4	10
R5	R4	20
R6	R4	20
A	R4	30
B	R4	30
C	C	10
D	R1	20
Default	R4	10

R3 Routing Table		
Dest.	NH	Cost
R1	R1	10
R2	R4	20
R3	-	-
R4	R4	10
R5	R4	20
R6	R4	20
A	R1	30
B	R4	30
C	R4	30
D	R1	20
Default	R4	10

R4 Routing Table		
Dest.	NH	Cost
R1	R3	20
R2	R2	10
R3	R3	10
R4	-	-
R5	R5	10
R6	R6	10
A	R6	20
B	R5	20
C	R2	20
D	R3	20
Default	R2	10

R5 Routing Table		
Dest.	NH	Cost
R1	R4	30
R2	R4	20
R3	R4	20
R4	R4	10
R5	-	-
R6	R4	20
A	R4	20
B	B	10
C	R4	30
D	R4	40
Default	R4	10

R6 Routing Table		
Dest.	NH	Cost
R1	R4	30
R2	R4	20
R3	R4	20
R4	R4	10
R5	R4	20
R6	-	-
A	A	10
B	R4	30
C	R4	30
D	R4	40
Default	R4	10

We have several information on the labels used:

R4 switching table:

(FEC)	***Label IN***	***Label OUT***	***Next Hop***
(FEC A)	6	1	R6
(FEC B)	2	5	R5
(FEC C)	7	8	R2
(FEC D)	3	10	R3

Hypotheses: The network operator is sought to minimize the number of labels used and to group streams having the same FEC as much as possible by assigning them the same label when possible.

The edge LSRs do the POPs.
The packets destined for A received by R2 carry a label equal to 12.
The packets destined for B received by R2 carry a label equal to 5.
The packets destined for C received by R2 carry a label equal to 8.
The packets destined for D received by R2 carry a label equal to 10.
When R1 receives a packet with an MPLS label equal to 6, it is bound for D.

Complete the forwarding table of R6. **1 mark per correct**

(FEC)	***Label IN***	***Label OUT***	***Next Hop***
(FEC A)			
(FEC B)			
(FEC C)			
(FEC D)			

Question 7 [6 Marks]

The measurements available on the CAIDA AS Rank ranking site reveal the properties of three autonomous systems (ASs), Level3, CTGNet (China Telecom) and KDC (Cona Hosting). On the CAIDA web page corresponding to the three ASs (see Table1), we can identify the number of neighbours under the heading "AS degree" and the term "global". These neighbours can be Internet service providers, AS with a peering agreement, or customers. Looking at the information providing on the table of each of the AS, answer the questions below.

CAIDA DATA FOR Level 3					
AS number	3356				
AS Name	Level3				
Organisation	Level 3 Parent, LLC				
Country	USA				
AS rank	1				
Customer cone	48548 asn	740857 prefix	191119864 address		
AS degree	6322 global	63220 transit	0 provider	67 peer	6255 customer

CAIDA DATA FOR CHINA TELECOM GLOBAL LIMITED					
AS number	23764				
AS name	CTGNet				
Ogarnisation	China Telecom Global Limited				
Country	Hong Kong				
AS rank	148				
Customer cone	346 asn	28846 prefix	123786317 address		
AS degree	637 global	632 transit	13 provider	546 peer	78 customer

CAIDA DATA FOR CONA HOSTING SDN BHD					
AS number	136209				
AS Name	KDC-AS-AP				
Ogarnisation	CONA HOSTING SDN BHD				
Country	Malaysia				
AS rank	16025				
Customer cone	1 asn	50 prefix	12800 address		
AS degree	5 global	0 transit	5 provider	0 peer	0 customer

a)	By observing the number of neighbours of Level3, and their types, indicate whether Level3 is a Tiers 1, Tiers 2 or Tiers 3	**2 Marks**
b)	By observing the number of CTGNET (China telecom Global Limited) neighbours and their types on table 1, indicate whether CTGNET is a Tiers 1, Tiers 2 or Tiers 3.	**2 Marks**
c)	By observing the number of neighbours of CONA and their types, indicate whether CTGNET is a Tiers 1, Tiers 2 or Tiers 3.	**2 Marks**

Question 8 [12 marks]		
a)	Give an example of an application-level requirement that might take advantage of the drop priority field in an ATM cell? List two reasons explaining your answer.	3 Marks
b)	For ATM networks to operate as part of IP networks, ATM needs to provide a form of IP addresses resolution using ARP protocol. However, the ARP procedure as described in an IP network cannot work because it depends on the fact that packets can be broadcast to all hosts in a single network. For this reason there is a different procedure of ARP that is defined for ATMs network and known as the ATMARP protocol. Under ATMARP, explain how does the ARP server learn the physical network addresses of the hosts in its subnet?	2 marks
c)	What percentage of an ATM link's total bandwidth is consumed by all no payload bits in AAL5 (ATM Adaptation Layer 5) when the user data is 512 bytes long?	3 marks
d)	The IP-datagram for a TCP ACK message is 40 bytes long: it contains 20 bytes of TCP header and 20 bytes of IP header. Assume that this ACK is traversing an ATM network that uses AAL5 to encapsulate IP packets. How many ATM packets will it take to carry the ACK? [2 marks]	4 marks

Question 9 [9 marks]

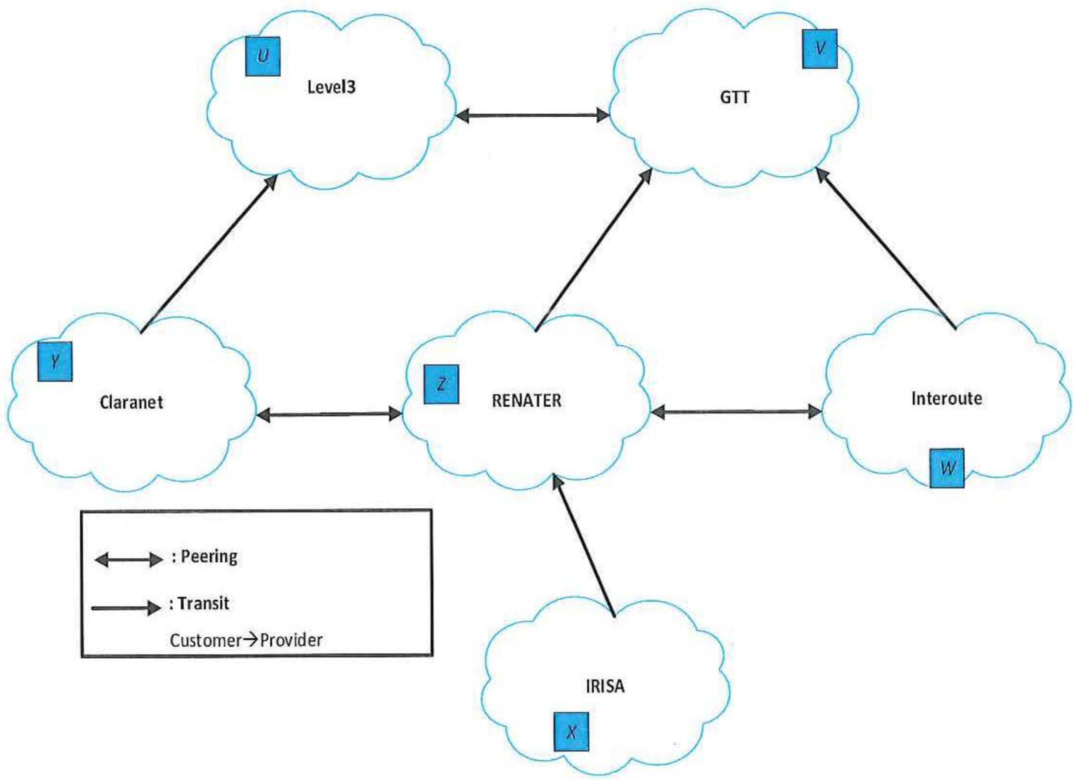
Consider a VC network with a 2-bit filed for the VC number. Suppose that the network wants to set up a virtual circuit over four links: link A, link B, link C and link D. Suppose that each of those links is currently carrying two other virtual circuits, and the VC numbers of these other VCs are as follows:

Link A	Link B	Link C	Link D
00	01	10	11
01	10	11	00

Assume that each of the existing VCs may only traverse one of the four links.

a)	If each VC is required to use the same VC number on all the four links along its path, what VC number could be assigned to the new VC?)	3 marks
b)	Give one reason why packets do not keep the same VC number on each of the links along its route	2 marks
c)	If each VC is permitted to have a different VC number in the different links along its path, how many different combinations of four VC numbers (one for each of the four links) could be used?	4 marks

Question 10 [4 marks]



a)	Looking at the topology in Figure 4 and the agreement between the ISPs. For a communication between IRISA and Interoute, what are the paths which respect the agreements between the autonomous systems?	**2 marks**
b)	According to the topology in Figure 4, what are the two implications of the agreement between Claranet and RENATER?	**2 marks**

==================**End** =================