NAMIBIA UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF COMPUTING AND INFORMATICS

DEPARTMENT OF COMPUTER SCIENCE

QUALIFICATION: BACHELOR OF COMPUTER SCIENCE	
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COURSE: BROADBAND NETWORKS	COURSE CODE: BBN810S
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DURATION: 3 HOURS	MARKS: 100

FIRST OPPORTUNITY EXAMINATION QUESTION PAPER	
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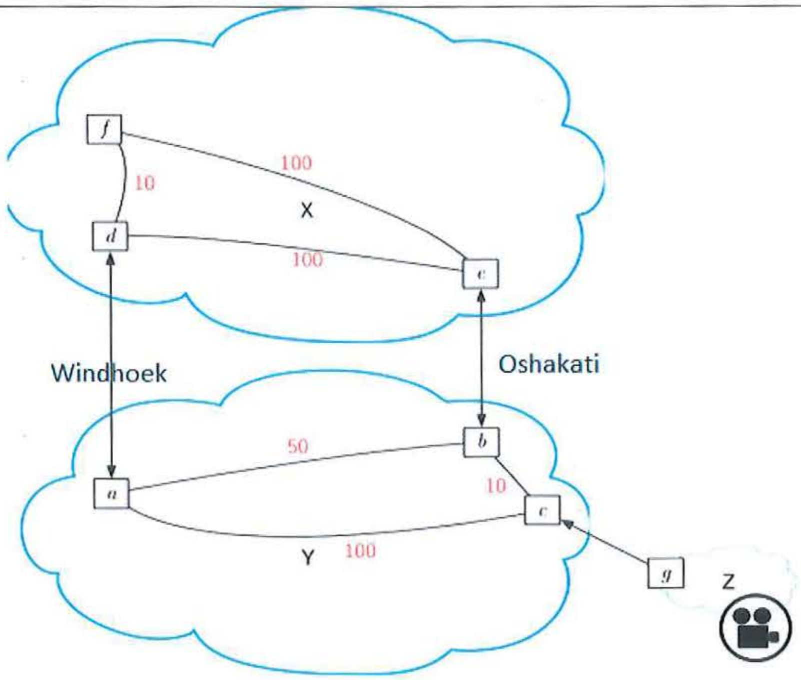
INSTRUCTIONS
1. Answer ALL the questions. 2. Write clearly and neatly. 3. Number the answers clearly.

THIS QUESTION PAPER CONSISTS OF 14 PAGES (Including this front page)

Question 1 [6 marks]		Marking Scheme
(a)	What is an advantage of statistical multiplexing over frequency division multiplexing?	2 marks
(b)	What is the difference between the flow control and congestion control mechanisms provided by TCP	2 marks
(c)	Why are ATM-based networks preferred to STM?	2 marks

QUESTION 2 [10 Marks]
We consider two Internet access providers who have deployed numerous points of presence in Namibia. These providers are identified by the autonomous systems denoted **X** and **Y**. Autonomous system **Z** is a video content delivery company connected to Y. The letters **a** through **g** represent IP routers on the networks of each of these autonomous systems. **X** and **Y** have entered into a peering agreement to exchange their traffic. This agreement is set up at an exchange point in Windhoek through routers **a** and **d**, and at an exchange point in Oshakati through routers **b** and **e**. **Z** has signed a transit agreement with provider Y. This agreement is implemented through routers **c** and **g**.



In the following, we assume that: BGP is enabled on all routers of all autonomous systems, the OSPF protocol is used for internal routing in each of the autonomous systems; the cost of each link is indicated in the figure; the identifiers of the routers are chosen in lexicographic order: the identifier of router **a** is smaller than that of router **b**... smaller than that of router **g**.

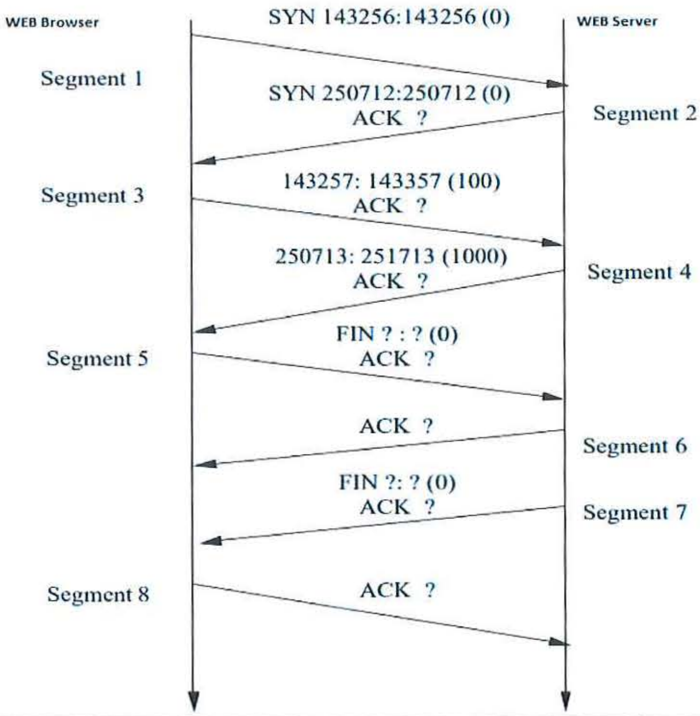
The autonomous **system Z** uses the IP address prefix **192.168.1.0/24** on its network (this prefix is chosen as an example and is not actually routed on the Internet). Study the propagation of routing information concerning prefix 192.168.1.0/24 and the resulting route selection, in particular on router **f,** and answer the following questions.

Question 2.1: In the figure 2, **router c** must maintain iBGP sessions with: (check the two correct answers) a) the router a. b) the router b. c) the router d. d) the router e. e) the router g.	**2 marks**
Question 2.2: In the previous figure 2, **router c** must maintain eBGP sessions with (select all applicable answers): a) the router a. b) the router b. c) the router d. d) the router e.	**1 mark**

e) the router g.	
Question 2.3: Using the BGP router g, what prefix(es) must Z announce to make its entire network reachable from the Internet?	**1 mark**
Question 2.4: How many iBGP advertisements does the **router a** receive containing the 192.168.1.0/24 prefix?	**1 marks**
Question 2.5: How many eBGP advertisements containing the 192.168.1.0/24 prefix does **router d** receive??	**1 mark**
Question 2.6: Taking into account the BGP advertisements received by **router d**, which BGP decision rule allows selecting **router a** as the next hop to the prefix 192.168.1.0/24?	**2 marks**
Question 2.7: Taking into account the BGP advertisements received by **router e**, what does it choose as the next hop to the **192.168.1.0/24** prefix?	**2 marks**

Question 3 [10 marks]	Marking Scheme

The TCP exchanges in figure 3 corresponds to the transfer of a **web page** between a **web browser** and a **web server**. We assume that the request to the web page is 100 bytes long and that the returned web page is **1000 bytes** long. There are no transmission errors. For each data segment, various information appears. First, the presence of one or more indicators such as **SYN**, **FIN**, and **ACK**. Furthermore, the first line contains two numbers. The first number corresponds to the sequence number of the first byte of the segment, and the second number corresponds to the number of the first byte of the next segment to be sent. The number in parentheses corresponds to the total number of bytes transmitted in the segment. If the segment carries a positive acknowledgment, the ACK indicator is indicated, and next to it must be the value of the TCP segment's acknowledgment field.



a)	Complete the missing sequence numbers (SN) and acknowledgment numbers (ACK) in the figure (which appear as question marks)?	**7 Marks (1 per correct answer)**
b)	What do the different TCP segments numbered from segment 1 to segment 3 correspond to?	**1 mark**
c)	What do the different segments numbered from segment 3 to segment 4 correspond to?	**1 mark**
d)	What do the different segments numbered from segment 5 to segment 8 correspond to?	**1 mark**

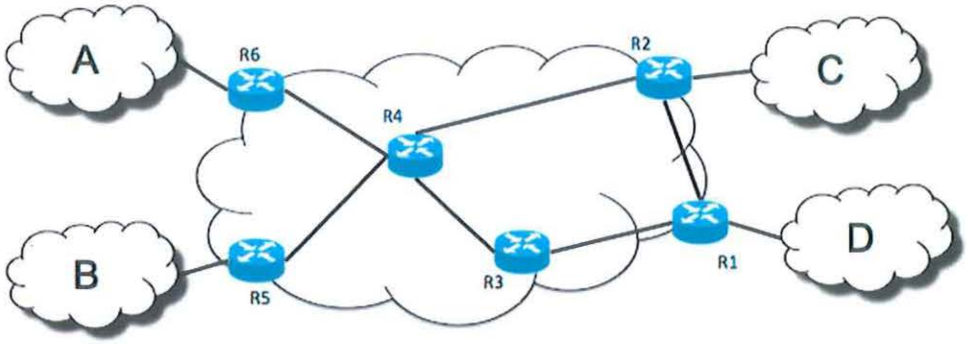
Question 4 [8 marks]		Marking Scheme
Suppose that a router has three input flows and one output port. It receives packets continuously as per table below, with all flows beginning at the same time and queues being empty before the arrival of the first packet. Packet order in each separate flow is listed 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.		
a)	In which order are packets transmitted by the router if Fair queuing is used?	4 marks
b)	In which order are packets transmitted by the router if 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

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

Question 5 [8 marks]		Marking Scheme
(a)	Why is round-trip time an appropriate time scale to retransmit packets?	2 marks
(b)	Let α=0.2. Suppose for a given TCP connection three acknowledgments have been returned with RTTs: RTT for first ACK = 80 msec; RTT for second ACK = 60 msec; and RTT for third ACK = 100 msec. Determine the value of Estimated RTT after each of the three acknowledgments.	4 marks
(c)	Name two factors that can cause variance in the network round-trip time?	2 marks

Question 6 [12 marks]	**Marking Scheme**

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 from 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.		
a)	Complete the forwarding table of R6.	**12 marks**
		1 mark per correct entry

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

Question 7 [6 Marks]	Marking Scheme
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 Tier 1, Tier 2 or Tier 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 [9 marks]		**Marking Scheme**
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**

Question 9 [9 marks]	**Marking Scheme**
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: Assume that each of the existing VCs may only traverse one of the four links.	

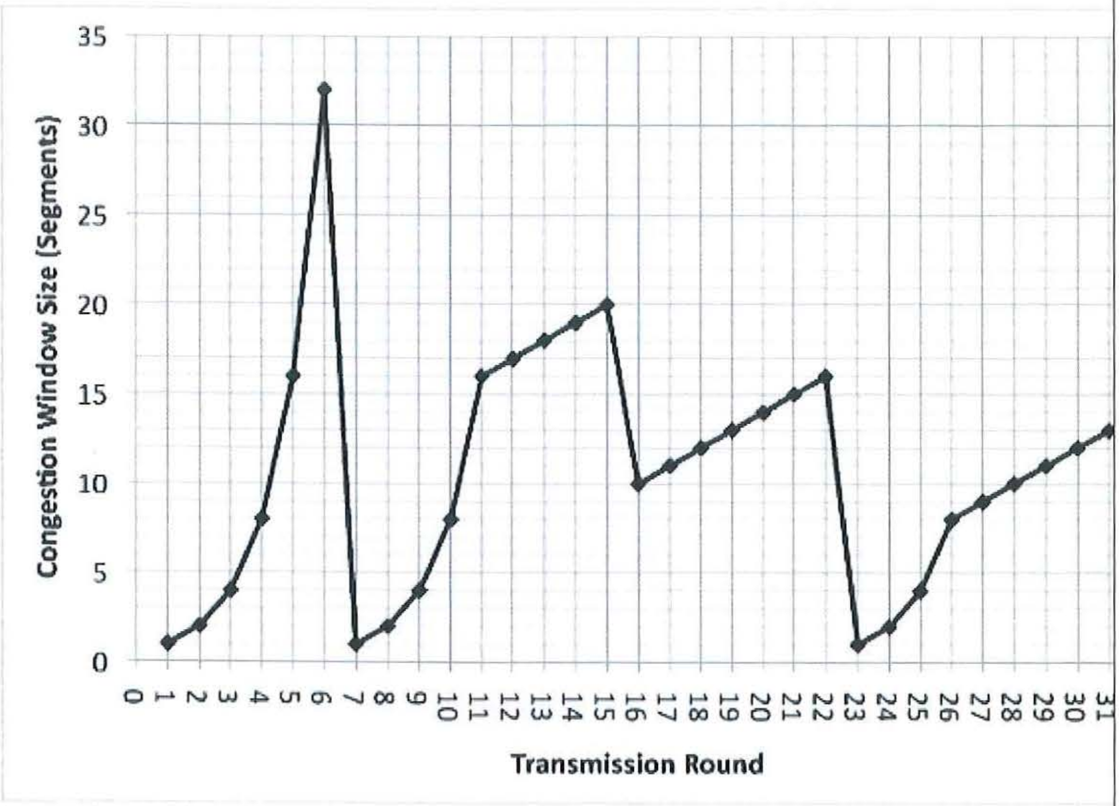
Link A	**Link B**	**Link C**	**Link D**
00	**01**	**10**	**11**

01	**10**	**11**	**00**	

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 (14 marks)

The Transmission Control Protocol uses a method called congestion control to regulate the traffic entering the network. The behaviour of TCP congestion control can be represented as a graph in which the x-axis indicates the time, and the y-axis indicates congestion window size. Please use the graph shown below to answer the following questions. Note that the graph does not explicitly show timeouts, but you should be able to figure out when timeouts happened based on the events shown.



a) *Give two reasons why slow start is used, and explain why it does a better job than congestion avoidance for that function.* **2 marks**

b) *Identify the intervals of time when TCP slow start is operating. For each interval, identify which of the above reasons apply and do not apply and explain why.* **2 marks**

c) *Identify the intervals of time when TCP congestion avoidance is operating. Why congestion avoidance should be used instead of slow Start during these intervals. Please clearly identify one specific reason* **2 marks**

d) Identify the intervals of time when TCP fast retransmission is used. Please explain what fast retransmission does and how it is triggered.	**2 marks**
e) Identify the intervals of time when TCP fast recovery is operating. What does fast recovery do and explain why is it beneficial?	**2 marks**
f) *Identify the interval(s) of time when fast recovery could have happened, but did not. Identify one specific example of a circumstance that may prevent fast recovery from happening.*	**2 marks**
g) Which version of TCP is represented in this Figure?	**2 marks**

Question 11 [8 marks]		**Marking Scheme**
a)	What percentage of an ATM link's total bandwidth is consumed by the ATM cell headers?	**2 marks**
b)	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?	**4 marks**
c)	Cell switching methods essentially always use virtual circuit routing rather than datagram routing. Give two arguments why this is so	**2 marks**

========================= **GOOD LUCK** =========================