NAMIBIA UNIVERSITY
OF SCIENCE AND TECHNOLOGY

FACULTY OF COMPUTING AND INFORMATICS

DEPARTMENT OF COMPUTER SCIENCE

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FIRST OPPORTUNITY EXAMINATION QUESTION PAPER	
EXAMINER(S)	**PROF GUY-ALAIN LUSILAO ZODI**
MODERATOR:	**PROF VELEMPINI MTHULISI**

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

THIS QUESTION PAPER CONSISTS OF 10 PAGES (Including this front page)

QUESTION III

Host A and B are communicating over a TCP connection, and Host B has already received all bytes up through byte 126 from Host A. Suppose Host A then sends two segments to Host B back-to-back. The first and second segments contain 80 and 40 bytes of data respectively. In the first segment, the sequence number is 127, the source port number is 302, and the destination port number is 80. Host B sends an acknowledgment whenever it receives a segment from Host A.

a) In the second segment sent from Host A to B, what is the sequence number, source port number, and destination port number? [3 marks]

b) If the first segment arrives before the second segment, in the acknowledgment of the first arriving segment, what is the acknowledgment number, the source port number, and the destination port number? [3 marks]

c) If the second segment arrives before the first segment, in the acknowledgment of the first arriving segment, what is the acknowledgment number? [2marks]

d) Suppose the two segments sent by A arrive in order at B. The first acknowledgment is lost and the second acknowledgment arrives after the first timeout interval. Draw a timing diagram, showing these segments and all other segments and acknowledgments sent. (Assume there is no additional packet loss.) For each segment in your figure, provide the sequence number and the number of bytes of data; for each acknowledgment that you add, provide the acknowledgment number. [6 marks]

QUESTION IV

Consider the Figure 1 below. Suppose that the video is encoded at a fixed bit rate, and thus each video block contains video frames that are to be played out over the same fixed amount of time of 1 second. The server transmits the first video block at t0=0sec, the second block at t=1 sec, the third block at t=2 sec and so on. Once the client begins playout, each block should be played out 1second after the previous block.

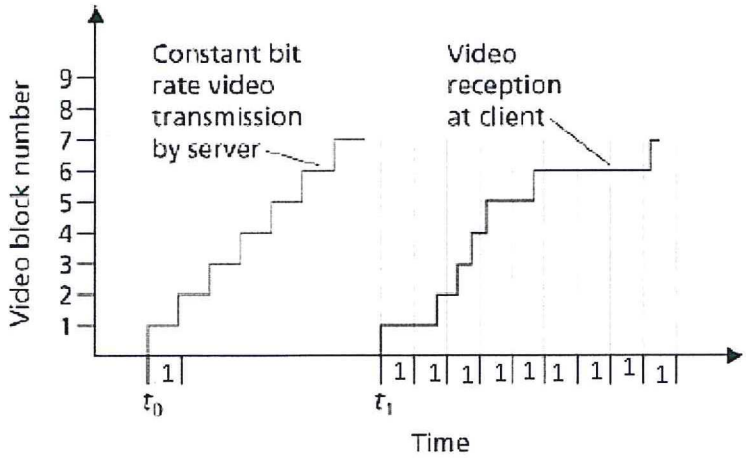

Figure 1. Video streaming transmssion

a) Suppose that the client begins playout as soon as the first block arrives at t1. In the figure above, how many blocks of video (including the first block) will have arrived at the client in time for their playout? Explain how you arrived at your answer. [2 marks]

b) Suppose that the client begins playout at t1+1. How many blocks of video (including the first block) will have arrived at the client in time for their playout? Explain how you arrived at your answer. [2 marks]

c) In the same scenario in (b), what is the largest number of blocks that will be stored in the client buffer, awaiting playout? Explain how you arrived at your answer. [2 marks]

d) What is the smallest playout delay at the client, such that every video block has arrived in time for its playout? Explain how you arrived at your answer. [2 marks]

QUESTION V

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. Packets in each separate flow are listed in the order they are received at the router. For example, packets 1, 3 and 6 are the first to arrive. Length represents the number of clock ticks it takes to transmit a packet. [5 marks]

Table 1. Queuing Router

Packet id	Length	Flow
1	200	1
2	200	1
3	160	2
4	120	2
5	160	2
6	210	3
7	150	3
8	90	3

Determine the order in which packets are transmitted by the router if Weighted fair queuing is used, with flow 2 having weight 2, and the other two with weight 1:

QUESTION VI

a) What percentage of an ATM link's total bandwidth is consumed by all non-payload bits in AAL5 (ATM Adaptation Layer 5) when the user data is 512 bytes long? [5 mark]

QUESTION VII

You are hired to design a reliable byte-stream protocol that uses a sliding window (like TCP). This protocol will run over a 100-Mbps network. The RTT of the network is 100 ms, and the maximum segment lifetime is 60 seconds.

(a) How many bits would you include in the AdvertisedWindow of your protocol header? [3 marks]

(b) How many bits would you include in SequenceNum fields, assuming a minimum packet size of 40 bytes? [2 marks]

QUESTION VIII

The Delta operator implements an IP / MPLS / Ethernet network whose topology is given in Figure. 2. Networks A, B, C, D and E are IP's networks.

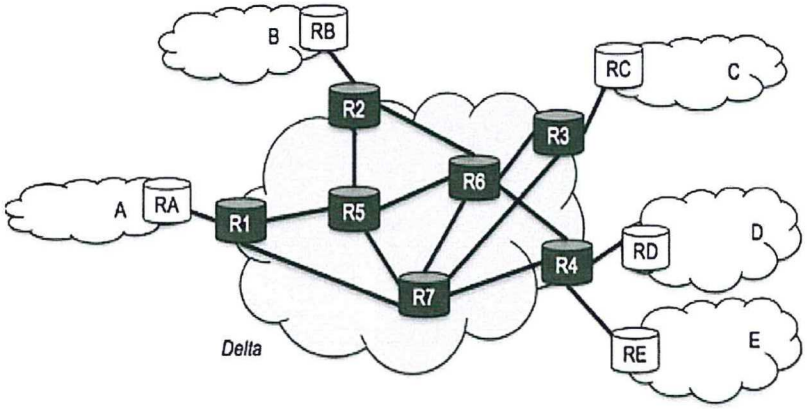

Figure 2. MPLS Network

The routing tables of the routers R1 to R7 are given in the Table 2.

Table 2. Routing Table

Routing Table R1		
Destination	Next Hop	Cost
R2	R5	1
R3	R7	2
R4	R7	2
R5	R5	1
R6	R5	2
R7	R7	1
NetworkA	RA	1
NetworkB	R5	3
NetworkC	R7	4
NetworkD	R7	3
NetworkE	R7	3

Routing Table R2		
Destination	Next Hop	Cost
R1	R5	2
R3	R6	2
R4	R6	2
R5	R5	1
R6	R6	1
R7	R5	2
NetworkA	R5	3
NetworkB	RB	1
NetworkC	R6	4
NetworkD	R6	3
NetworkE	R6	3

Routing Table R3		
Destination	Next Hop	Cost
R1	R7	2
R2	R6	2
R4	R6	2
R5	R6	2
R6	R6	1
R7	R7	1
NetworkA	R7	3
NetworkB	R6	3
NetworkC	RC	1
NetworkD	R6	3
NetworkE	R6	3

Routing Table R4		
Destination	Next Hop	Cost
R1	R7	1
R2	R6	2
R3	R6	2
R5	R7	1
R6	R6	2
R7	R7	1
NetworkA	R7	1
NetworkB	R6	3
NetworkC	R6	4
NetworkD	RD	3
NetworkE	RE	3

Routing Table R5		
Destination	Next Hop	Cost
R1	R1	1
R2	R2	1
R3	R6	2
R4	R6	2
R6	R6	1
R7	R7	1
NetworkA	R1	2
NetworkB	R2	2
NetworkC	R6	3
NetworkD	R6	3
NetworkE	R6	3

Routing Table R6		
Destination	Next Hop	Cost
R1	R5	2
R2	R2	1
R3	R3	1
R4	R4	1
R5	R5	1
R7	R7	1
NetworkA	R1	3
NetworkB	R2	2
NetworkC	R3	2
NetworkD	R4	2
NetworkE	R4	2

Routing Table R7		
Destination	Next Hop	Cost
R1	R1	1
R2	R5	2
R3	R3	1
R4	R4	1
R5	R5	1
R6	R6	1
NetworkA	R1	2
NetworkB	R5	3
NetworkC	R3	2
NetworkD	R4	2
NetworkE	R4	2

It is assumed that the Delta network administrator has enabled MPLS on his network. Equipment R1 to R7 are Label Switch Routers (LSP). (They switch packets using label. LSPs are built on demand; that is, we wait until the path is necessary to build it. The Delta network does not implement quality of service.

An IP packet is sent from a computer in Network A to another computer in Network D. The packet is forwarded by router RA via the Delta Network Router R1with a TTL of 40. Router R1 is the Border Router receiving the packet. It will trigger the creation of the LSP that will route the packets to network D. It is assumed that this LSP is the first to be created in the network.

a) Which router will choose the label to use the LSP link at the exit of R1 (LSP R1 to R7) towards Network D? [2 marks]

b) The switching table in R1 contains the following line:

Entry Label	Next host	Release Label
D	R7	5

In case the IP packet is to leave the Delta network, which router pops the MPLS header? [2 marks]

c) Which LSR will send the packets to router R4 for the communication from R1 to D? [2 marks]

d) Which next hop is associated with these packets in the switching table of R4? [2 marks]

e) If packets leave router R7 are labelled 9, draw the switching table of router R7. [3 marks]

QUESTION IX

a) Consider 10 flows passing through a Fair Queue (FQ) router with an outgoing (4) 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? [3 marks]

b) Assume with a link of capacity 10 Mbps that is traversed by four flows with arrival rates of 6, 4, 2, and 1 Mbps, respectively. How much bandwidth will each flow get? (Show all your calculations.) [2 marks]

QUESTION X

Using the network in Figure 3, give the virtual circuit tables for all the switches after each of the following connections is established. Assume that the sequence of connections is cumulative; that is the first connection is still up when the second connection is being established and so on. Also assume that the VCI assignment always picks the lowest unused VCI on each link, starting with 0. [6 marks]

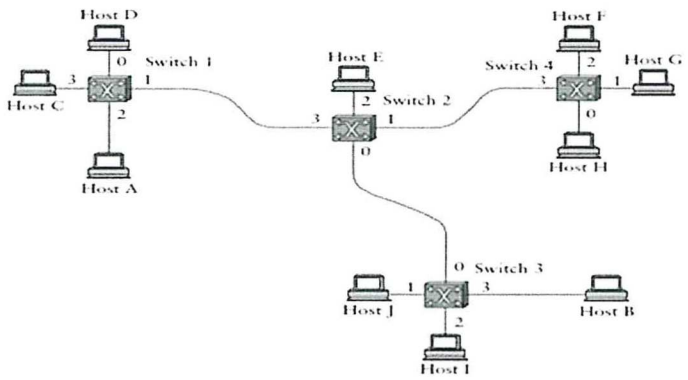

Figure 3. VC Network

1) Host D connects to host H (1 mark)
2) Host B connects to host G (1 mark)
3) Host F connects to host A (1 mark)
4) Host H connects to host C (1 mark)
5) Host I connects to host E (1 mark)
6) Host H connects to host J (1 mark)

QUESTION XI

The Transmission Control Protocol uses a method called congestion control to regulate the traffic entering the network. The behavior 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 Figure 4 to answer the following questions (Note that the Figure 4 does not explicitly show timeouts, but you should be able to figure out when timeouts happened based on the events shown).

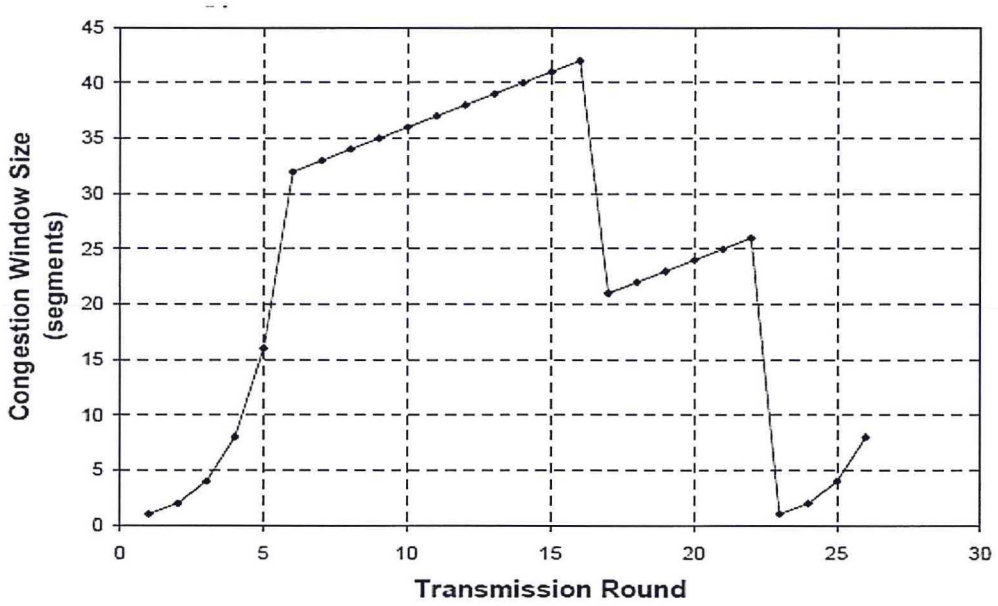

Figure 4. TCP Congestion Window Size

a) Give two reasons why slow start is used, and explain why it does a better job than congestion avoidance. [2 marks]

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

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

d) After the 16th transmission round, a loss of segment 3 is detected by a triple duplicate ACK or by a timeout? Explain your answer. [2 marks]

e) What is the value of ssthreshold (slow start threshold) at the 18th transmission round? [2 marks]

f) Assuming a packet loss is detected after the 26th round by the receipt of a triple duplicate ACK, what will be the values of the congestion window size and of ssthresh? [2 marks]

g) Suppose TCP Tahoe is used (instead of TCP Reno), and that triple duplicate ACKs are received at the 16th round. What is the value of the ssthresh and the size of the congestion window size after the 19th round? [2 marks]

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