RHODES UNIVERSITY
DEPARTMENT OF COMPUTER SCIENCE

EXAMINATION: JUNE 2018

COMPUTER SCIENCE HONOURS
PAPER 3 – REAL TIME MULTIMEDIA

Internal Examiner: Dr. M Tsietsi

External Examiner: Prof. M Kuttel

MARKS: 120
DURATION: 2 hours

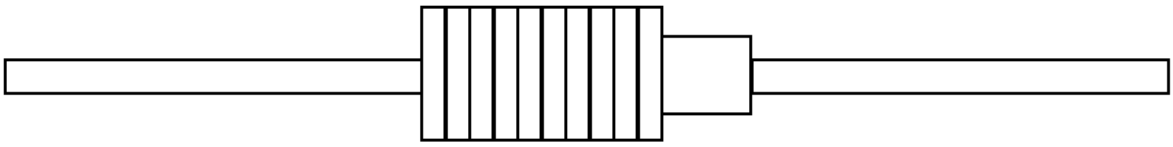
GENERAL INSTRUCTIONS TO CANDIDATES

1. There are 5 pages and 6 questions. **PLEASE MAKE SURE THAT YOU HAVE A COMPLETE PAPER.**
2. Read all questions carefully.
3. Please number your answers clearly.
4. State **any** assumptions and show all workings.
5. Diagrams are encouraged and should be clearly and neatly labelled.
6. Provide answers that are concise, legible, and clearly numbered.
7. Answer all questions in the answer book provided OR in your preferred word processor and save regularly to your Exam Folder.
8. If answering online, diagrams may be drawn by hand in the answer book provided, and must be referred to with a unique diagram number.
9. The use of a calculator **is** permitted for this examination.
10. The Concise Oxford English Dictionary may be used during this examination.

PLEASE DO NOT TURN OVER THIS PAGE UNTIL TOLD TO DO SO.

QUESTION 1 **(2 + 2 + 3 + 3 = 10 Marks)**

The image below depicts the incoming line, queue, outgoing interface and outgoing line of a Layer 3 Internet Protocol (IP) router.



a) If the line supports an ingress rate of 500 packets/sec and the router supports a transmission rate of 500 packets/sec, what behavior can be expected to emerge inside the router over time? Explain your answer.

b) Let `L` denote the average size of a packet (in bytes), `a` denote the ingress rate of arrival and `R` be the transmission rate. Using these variables, give an expression that can be used to identify the conditions under which congestion would occur.

c) RED (Random Early Detection) is an active queue management (AQM) algorithm that operates on routers in order to help avoid congestion collapse on the Internet.

   i. Define *global synchronisation* and explain how *aggressive applications* exploit it.

   ii. Explain how RED mitigates the negative effects of global synchronisation.

QUESTION 2 **(6 + 6 + 8 = 20 Marks)**

Network neutrality has become a hot topic of late and follows naturally from discussions on the evolution of the Internet and the treatment of classes of traffic flows by Internet Service Providers (ISPs).

a) Name and describe the three principles on which network neutrality is founded, according to the Federal Communications Commission (FCC) in the United States.

b) For each of the principles you have identified in your answer to (a) above, give an example of how that principle has been or could potentially be violated by ISPs.

c) Give a brief account of network neutrality regulation, summarising and differentiating between the first and second Open Internet orders.

QUESTION 3 **((2 + 4) + 10 + 3 + 4 + 3 + 12 = 38 Marks)**

Figure 1 shows the layout of a portion of a campus Ethernet network, depicting a small number of participants, a campus radio streaming server and an edge router.

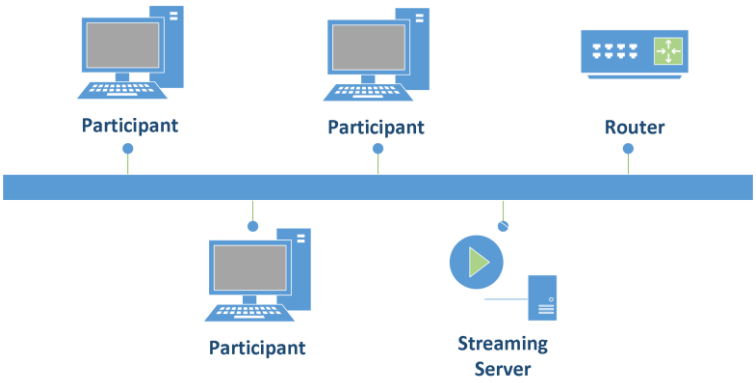


Figure 1 Participants, Streaming server and Edge Router.

a) Certain streaming services such as Netflix and YouTube stream media content over HTTP (Hypertext Transfer Protocol), whereas others decompose the streaming model to allow HTTP to be used only as an "out-of-band" protocol for obtaining textual metadata descriptions.

i. In the second case, identify and describe the mix of protocols that can be used to establish multimedia streaming in the absence of HTTP.

ii. Discuss two advantages of this streaming modality as compared with HTTP.

b) IP multicast has been proposed as a way of transmitting media content to a set of interested participants. Explain in detail, using a suitable diagram, how an IP multicast streaming overlay is constructed and maintained.

c) Briefly describe how routers are able to keep track of the presence of multicast group members so that multicast traffic is only forwarded to group participants.

d) Table 1 summarises the properties of four commonly used audio codecs. With reference to at least two of the codecs listed above, discuss the trade-off between latency and packet overhead.

Codec	**Bit rate**	**Sample period**	**Frames per packet**
G.711 (PCM)	64 kbps	20 ms	1
G.723.1A (ACELP)	5.3 kbps	30 ms	1
G.728 (LD-CELP)	16 kbps	2.5 ms	4
G.729A (CS-CELP)	8 kbps	10 ms	2

Table 1 Audio Codec properties.

e) Suppose that the streaming server wishes to conserve bandwidth by occasionally downgrading the codec in response to indications of jitter and packet loss. On a certain day, its behaviour was observed over a ten minute period, during which it streamed G.711 audio for 2 minutes, followed by G.728 for 3 minutes and lastly G.723.1A for 5 minutes.

Identify and outline the behaviour of a mechanism through which the assessment of the quality of a real-time stream as pertains to packet loss and delay jitter can be measured in order to facilitate such an active response. The mechanism you elect must be independent on the transport protocol.

f) Given the timelines given in (e) above and that the total header cost for communicating over an Ethernet network is 78 bytes, calculate the total amount of data generated (expressed in KB) of a single transmission stream from the server over that 10 minute period.

QUESTION 4 **(2 + 10 + 10 + 4 = 26 Marks)**

a) It is generally recommended that SIP UA (Session Initiation Protocol User Agents) *not* be configured with the IP address form of their outbound proxy. Identify two reasons why this is so.

b) Draw a diagram illustrating the SIP trapezoidal model. In reference to your diagram and to the nodes defined therein, explain all DNS (Domain Name System) related processes that occur and where they occur.

c) Assuming that a UA is configured with the hostname `example.com` as its outbound proxy. Provide a detailed discussion of the series of processes that must occur and the type of DNS records (providing example data wherever necessary) that are encountered with to ultimately deliver the forms of data required for the UA to communicate with its outbound proxy.

d) Discuss the trade-off between low and high expiry values for SIP location records.

QUESTION 5 **(4 + 6 + 2 = 12 Marks)**

Figure 2 illustrates a signalling relationship between two users, one of whom has a device with a private IP address (left) while the other (right) possesses a public IP address. A SIP proxy and a media relay, both of which have public IP addresses, mediate their interactions.

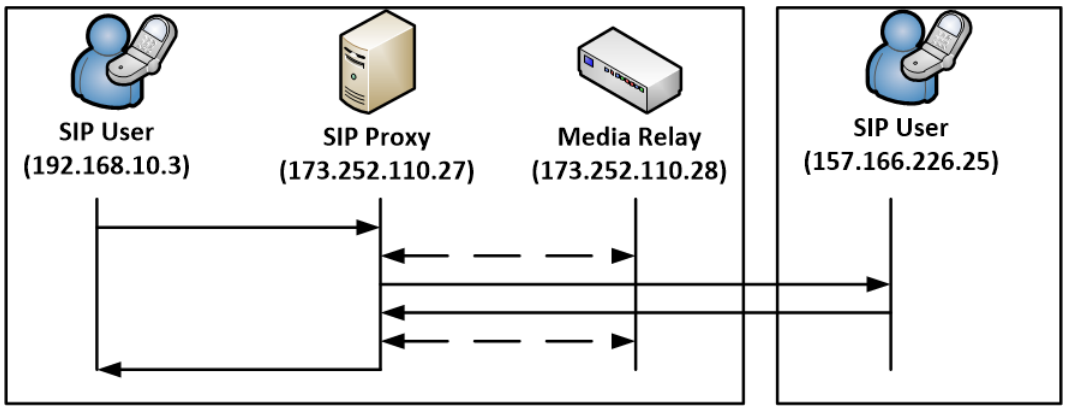


Figure 2 Two SIP UAs, a SIP proxy and a Media relay.

a) In relation to the Session Description Protocol (SDP) payload contained in the SIP messages, describe how a situation emerges that is characterised by "one way audio" in the absence of a media relay

b) Describe the algorithm by which a media relay implements in conjunction with the proxy server in order to support media communication between two users.

c) Within the context of the offer answer model, two SIP UAs that cannot agree on the parameters of a media session will fail to communicate. If we were to extend the capabilities of the media relay, describe an ability that we would have to add in order to assist communication between the two.

QUESTION 6 **(6 + 8 = 14 Marks)**

Implementers of SIP networks are keenly interested in modelling traffic so that they can better understand how their infrastructure and networks will respond in different situations. For this purpose, test tools and traffic generators such as SIPp enable implementers to conduct trials by configuring a set of conditions that can be modelled in an XML format in order to simulate real-world conditions.

a) Aside from performance testing, describe how a tool like SIPp could be used to test a SIP server for compliance to the rules of the SIP protocol, and for support of new or emerging protocol features. Give examples as necessary.

b) Describe the SIP benchmarking methodology in detail including all elements that are included and their defined roles. Indicate the main metrics that benchmarking attempts to quantify and how these are measured.

END OF EXAMINATION