University of KwaZulu-Natal

Electrical, Electronic and Computer Engineering

Examinations: **June 2026**
Subject & course code: **Data Communications: ENEL4DT**

Duration: Two Hours **Total Marks: 80**

Examiner/s: Prof Tahmid Quazi (Internal)
Prof Jules Moualeu (External)

Instructions:
1. This paper consists of **four** questions. ***Answer all four questions.***
2. All questions must be answered in full. All relevant assumptions must be documented clearly. Use diagrams where possible.
3. Scientific calculators may be used.
4. No notes of any kind are allowed. Useful data is attached at the end of the question paper.

Question 1 **[20]**

A. If you are designing an audio conferencing application over a multi-hop network.
i. List a set of Quality of Service (QoS) metrics that would inform the design. Give a short definition for each metric along with its unit to explain how it would affect the user experience. [6]
ii. What networking functionality would you have to implement to handle mobility? Give an explanation for each functionality you list [4]

B. Show by means of a mathematical derivation how a multi-stage switch can significantly minimise the number of cross-points when compared to a crossbar switch with the same number of inputs. Assume that the 3-stage switch meets the non-blocking condition of $k = 2n - 1$.
i. Derive the expression for the minimized number of cross-points. [7]
ii. Compare, by means of a numerical example for the number the number of inputs (N), the number of crosspoints for the multi-stage and a non-optimized crossbar switch. [3]

Question 2 **[20]**

A. Study the bit structure of a DS-1 digital stream frame shown in Figure 1.
i. Calculate of the DS-1 stream bit rate with a frame transmission rate of 8000 frames/sec. [4]
ii. Calculate the bit rate of a DS-2 signal which consists of 4 DS-1 signals and 136 kilobits of synchronisation information. [2]

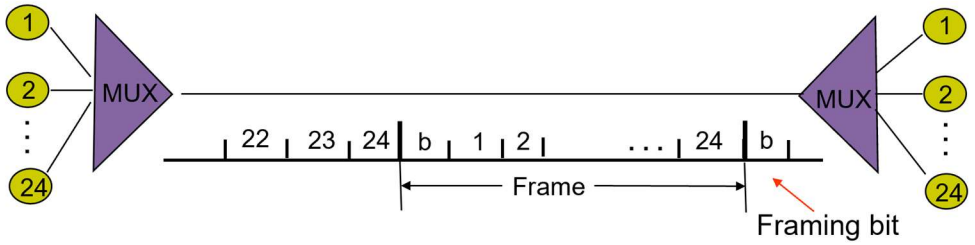

Figure 1: DS-1 digital stream frame structure

B. Figure 2 shows a block diagram of an access multiplexer used for oversubscription.

i. Define the variables ***N***, ***c***, and ***r*** used to calculate oversubscription. [3]

ii. State the formula for the oversubscription rate. [2]

iii. If ***N***, ***c***, and ***r*** are 40, 20 Mbps and 2 Mbps, respectively, and the ISP has allocated a total uplink capacity (***C***) of 180 Mbps to the packet network, calculate the subscriber **activity factor** and the **oversubscription rate**. [9]

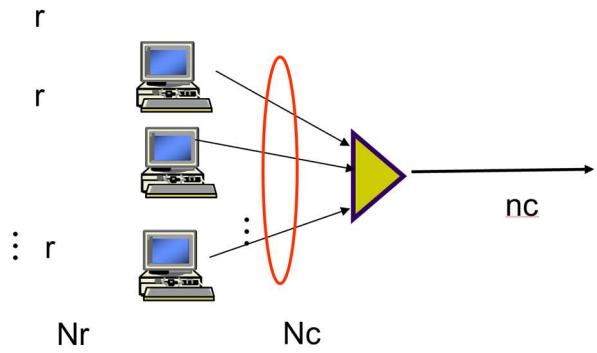

Figure 2: Access Multiplexer

Question 3 **[20]**

A. Suppose a new "Mini-Cell" carrier protocol is proposed to reduce delay. These cells have a 2-byte header and a 14-byte payload. An IP packet with a 20-byte header and 140-byte payload is mapped into these cells. [6]

i. Calculate the number of Mini-Cells required.

ii. What is the resulting header overhead percentage?

B. Study the network diagram showing nodes and paths costs shown in Figure 3. Apply Dijkstra's routing algorithm to show the converged routing table for source node A. Draw the tree diagram showing the final routes. [5]

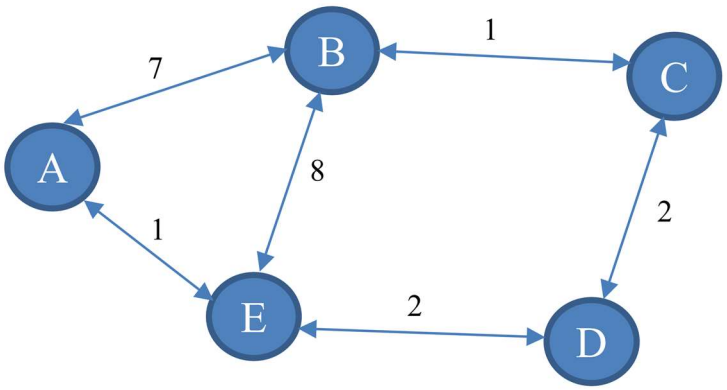

Figure 3: Network Diagram

C. Use Shannon's capacity formula to calculate the bandwidth required to achieve a bit rate of 4.5 Mbps over a channel with an SNR of 10 dB? [4]

D. Assuming 4-bit words, calculate the Internet Checksum using binary arithmetic if two symbols with values 15 and 5 are being transmitted. [5]

Question 4 **[20]**

A. Derive an expression for the expected delay of the GBN ARQ scheme. Clearly show your formulation, define your variables, and show each step of the derivation. [10]

B. A 1 Mibi-byte file is to be transmitted over a 1 Mbps communication line that has a bit error rate of $p = 10^{-6}$. The system utilises GBN ARQ with a window size of Ws=11 to account for the delay-bandwidth product. Neglect overhead for headers and CRC bits.

i. Suppose the file is broken into N=800 equal-sized blocks. Calculate the probability that a single block incurs an error (P_f). [4]

ii. Calculate the transmission time (t_f) for a single block. [2]

iii. On average, how long does it take to deliver the **entire file** using Go-Back-N ARQ? [4]

DATASHEET

$$Total\ Delay = L\tau + LP + (k-1)P$$

Overflow Probability: $$Q_n = \sum_{k=n+1}^{N} \left(\frac{r}{c}\right)^k \left(1-\frac{r}{c}\right)^{N-k}$$

$$\sum_{n=0}^{\infty} na^n = \frac{a}{(1-a)^2} \qquad |a| < 1$$

$C = W_c \log_2 (1 + SNR)$ bps