



Strathmore
UNIVERSITY

SCHOOL OF COMPUTING AND ENGINEERING SCIENCES
BACHELOR OF COMPUTER NETWORKS AND CYBER SECURITY
END OF SEMESTER EXAMINATION

CNS 2204: COMPUTATIONAL MODELLING

DATE: 8th December, 2022

Time: 2 Hours

Instructions

1. This examination consists of FIVE questions.
2. Answer **Question ONE (COMPULSORY)** and any other **TWO** questions.

QUESTION ONE

(Total:30 Marks)

- a. A system model can be categorized as deterministic or stochastic. Discuss these two concepts briefly. (2 Marks)
- b. The mean number of VoIP calls in a given network is 4 per day. Using Poisson's distribution, find the probability that in a given day;
 - i. There are exactly 3 VoIP calls. (3 Marks)
 - ii. There are more than 3 VoIP calls. (3 Marks)
- c. Spanning Tree Protocol (STP) is a Layer 2 network protocol used to prevent looping within a network topology. STP was created to avoid the problems that arise when computers exchange data on a local area network (LAN) that contains redundant paths. Figure 1 shows a network (*undirected graph*) consisting of 5 nodes with their associated path costs. Develop a spanning tree with the node C as the root based on the shortest path. *Show all the steps, i.e. hops and cost metric* (5 Marks)

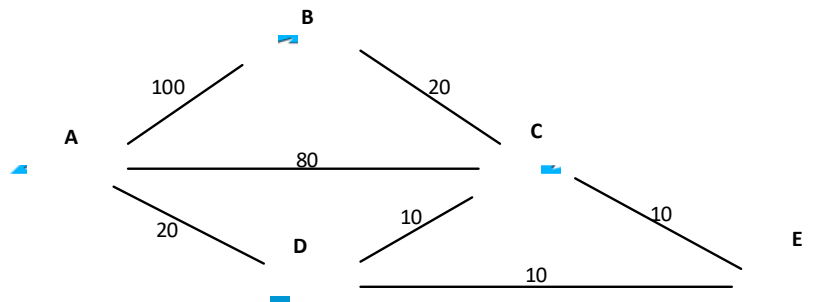


Figure 1

- d. For the design of a backbone network, figure 2 below shows six nodes and seven links with the associated link costs. If host 6, connected to node D originates a packet to be delivered to hosts {3,4,5,7}, show with arrows and appropriate labels how the packet travels through the network and provide link costs based on Dijkstra's algorithm. (8 Marks)

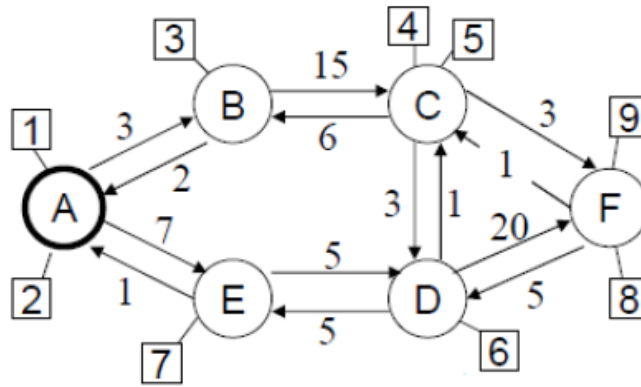


Figure 2

- e. State the meaning of each letter in the Kendall's notation (A/S/m/B/K/SD) queueing discipline and give an example of how it is used in networking. (5 Marks)
- f. A Markov chain or Markov process is a stochastic model describing a sequence of possible events in which the probability of each event depends only on the state attained in the previous event.
- What is the transition diagram of a Markov chain? (1 Mark)
 - Determine the state transition matrix of a Markov chain transition diagram in figure 3 below. (3 Marks)

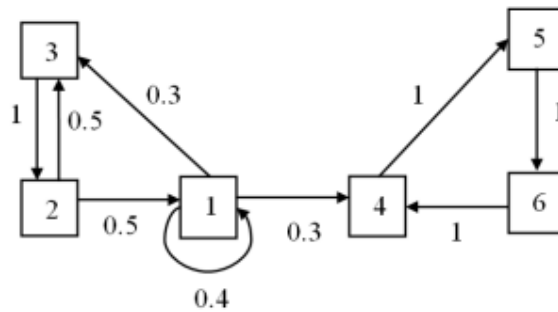


Figure 3

QUESTION TWO

(Total: 15 Marks)

- a. A random test was carried out to test WiFi signal strength of different WiFi access points at a given distance and the results were as follows;
(20, 15, 26, 32, 18, 28, 35, 14, 26, 22, 17) mW
Identify the outliers in the measurements using normal probability distribution. (show all the steps). (7 Marks)
- b. VoIP Customers (*requests*) arrive according to Poisson Distribution at an average of 10 customers per hour (8:00 – 9:00 am) on a given day.
- Find the probability that there are 2 customers between 8:00 and 8:20 am. (3 Marks)
 - Find the probability that there are 3 customers between 8:00 and 8:20 and 7 customers between 8:20 and 9:00 am. (3 Marks)
 - Find the probability (*in percentage*) that 5 customers will arrive between 10:00 and 10:30 in the morning (2 Marks)

QUESTION THREE**(Total: 15 Marks)**

- a. The network traffic data show in table 1 was collected by a system admin for a period of 20 Hrs.

Table 1

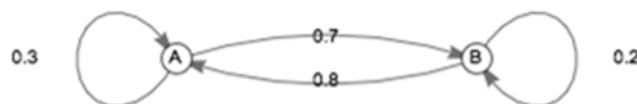
User	1	2	3	4	5
Time spent on a Site (mins)	10	7	28	20	35

Apply agglomerative hierarchical clustering to group collected data into clusters and identify the outliers (*if any*). Show the final clustering in a dendrogram with a set distance threshold of 12. Show all the steps (8 Marks)

- b. A box contains 1 CAT 7 cable and 10 CAT 6 cables. The cables are indistinguishable as they have similar cable colour and RJ45 termination. If one is to pick a cable from the box without checking the label or testing, all the cables will be equally likely to be selected. If we pick 5 cables from the box at once, what is the probability that this collection of 5 cables contains CAT 7 cable? Use hypergeometric distribution method (4 Marks)
- c. The measurements 0.60 mm, 0.52 mm, 0.51 mm were taken during a lab experiment. Find the relative error (in percentage) in the average of the collected data given a true value of 0.5 mm. (3 Marks)

QUESTION FOUR**(Total: 15 Marks)**

- a. In a given network, traffic to a message switching center for one of the outgoing communication lines arrive in a random pattern at an average rate of 320 messages per minute. The line has a transmission rate of 400 characters per second. The message length distribution (including control characters) is approximately exponential with an average length of 84 characters. Assuming that a very large number of message buffers are provided, calculate the following principal statistical measures of system performance;
- i. Average number of messages in the system (2 Marks)
 - ii. Average number of messages in the queue waiting to be transmitted. (2 Marks)
 - iii. Average time a message spends in the system. (2 Marks)
 - iv. Average time a message waits for transmission (2 Marks)
 - v. Probability that 15 or more messages are waiting to be transmitted. (2 Marks)
- b. A (time-homogeneous) Markov chain built on states A and B is depicted in the figure 4 below. By using transition matrix, determine the probability that a process beginning on B will be on B after 3 moves? (5 Marks)

*Figure 4*

QUESTION FIVE

(Total: 15 Marks)

- a. Table 2 below shows data used to illustrate the problem of gauging the similarity and diversity of sample sets based on Jaccard index.

Table 2

	Q1	Q2	Q3	Q4	Q5	Q6
X	1	0	0	1	1	1
Y	0	1	1	0	1	0

Determine;

- i. Jaccard similarity between binary vectors X and Y (2 Marks)
 - ii. Jaccard similarity between binary vectors X and Y (2 Marks)
- b. According to Minmax-Maxmin game theory principle, the selection of an optimal strategy by each player without the knowledge of the competitor's strategy is the basic problem of playing games. The objective of the study is to know how these players select their respective strategy so that they may optimize their pay off.
- i. Describe the three key elements in game theory. (3 Marks)
 - ii. To decide which internet service provider (ISP) to use in an area where two ISPs A and B overlap (*figure 5*), their signal strengths are matched based on Minmax-Maxmin game theory principle. If their signal strengths match, ISP A wins two units of value. If their signal strengths do not match, then ISP B wins 2 units of value. Determine the optimum strategies for these players and the value of the game. (*hint: construct the pay off matrix and determine whether it is a fair game and calculating their optimal mixed strategies*) (8 Marks)

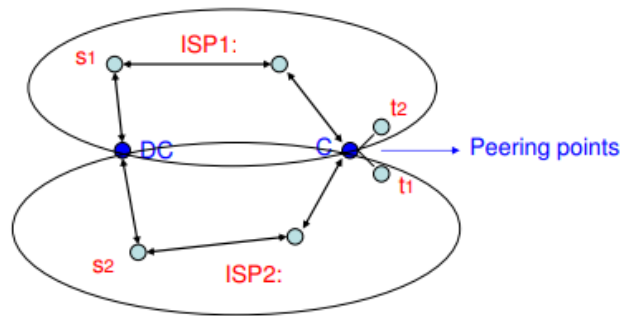


Figure 5