



### Special instructions for students

1. Mean delay for the M/M/1 system may be taken as

$$T = \frac{1}{\mu - \lambda}$$

where

$\lambda$  = arrival rate at M/M/1 system [packets / s], and

$\mu$  = service rate of M/M/1 system [packets / s].

1.

- a) For a simplified version of automatic repeat request (ARQ) scheme:

$$a = \frac{\text{propagation time}}{\text{transmission time}}$$

- i) Derive a simple expression for the performance of the selective repeat ARQ mechanism with window size equal to 2 packets. Consider that a single frame is in error with probability  $P = 0.01$  and  $a = 1$ . [5]

- ii) Derive a simple expression for the performance of the selective repeat ARQ mechanism with window size equal to 4 packets. Consider that a single frame is in error with probability  $P = 0.01$  and  $a = 1$ . [5]

- b)  $N$  computer terminals are connected using a LAN 1-persistent CSMA/CD protocol. If the probability that a station transmits during an available time slot is  $P$ ,

- Derive the probability that a successful transmission will take  $j$  attempts.

[10]

2.

- a)

- i) Describe and discuss the operations of an LEO satellite system. What is its main difference from other satellite systems (e.g. GEO and MEO)? [5]

- ii) Describe and discuss all possible handovers that need to be considered in an LEO satellite system. [5]

- b) The steady state solution of a two-state voice source model is given by

$$\Pi = \left[ \frac{\lambda}{\alpha + \lambda}, \frac{\alpha}{\alpha + \lambda} \right]$$

- i) Define and explain the parameters  $\alpha$  and  $\lambda$ . [3]

- ii) For  $N$ -multiplexed independent sources, derive the steady state probability of having  $i$  sources on. [7]

3.

- a) The network of Fig 3.1. has been formed by the inter-connection of two sub-networks namely,  
Sub-network A nodes {1, 2, 3, 4} and,  
Sub-network B nodes {4, 5, 6, 7}

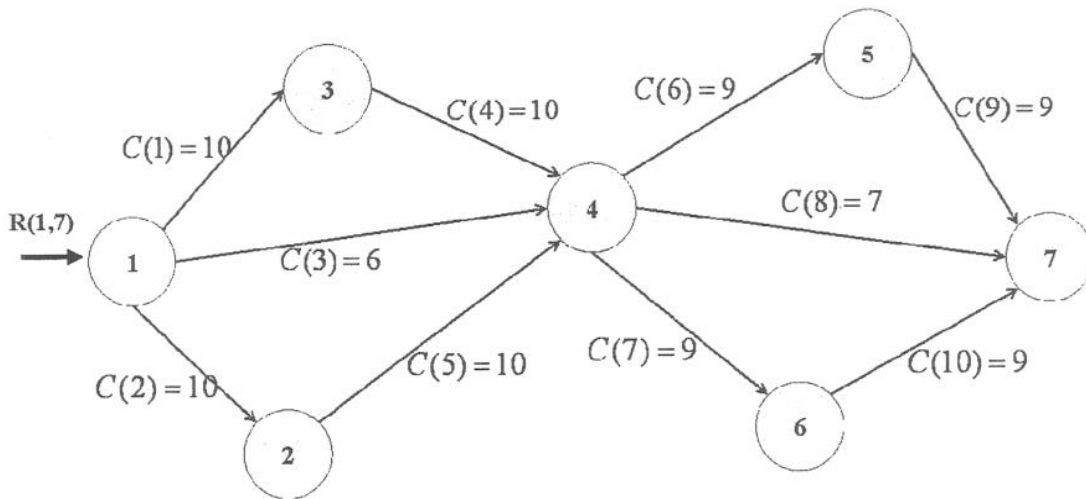
- i) Solve the Optimal Routing Problem for the O-D demand  $R(1,7) = 10$  [kbit/s] for the network of Figure 3.1.

[10]

- b) If you have the possibility of increasing up to 1 [kbit/s] of capacity between any two points of one particular sub-network,

- i) Suggest possible ways of lowering the level of network congestion.  
Explain your decision.  
What will be the new mean network delay?

[10]



Note: All capacities in the network  $C(i)$  are given in [kbit/s]

Figure 3.1

4.

a)

i) Describe and discuss the Bellman-Ford shortest path algorithm.

[5]

ii) Describe and discuss Dijkstra's shortest path algorithms.

[5]

b)

i) For the network of Figure 4.1. show clearly the iterative sequence of the Bellman-Ford algorithm.

[5]

ii) For the network of Figure 4.1. show clearly the iterative sequence of Dijkstra's algorithm.

[5]

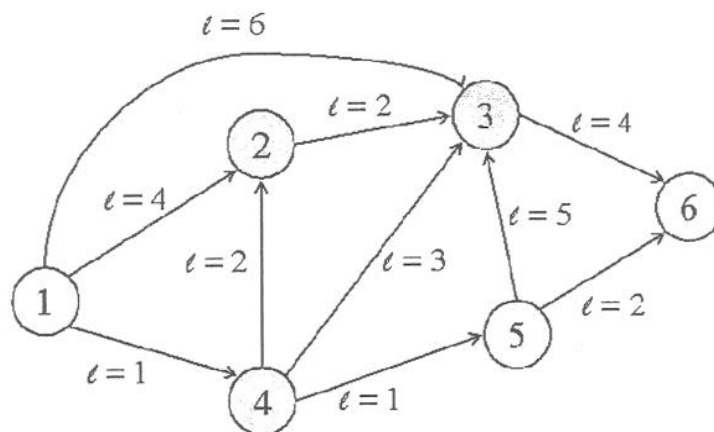


Figure 4.1

5.

a)

i) Briefly discuss the advantages of implementing DiffServ over Multi-Protocol Label Switching.

[6]

ii) Discuss the main benefits that Multi-Protocol Label Switching brings to IP-based network.

[7]

b) In the context of an ATM networks the equivalent capacity function can be expressed by:

$$C^* = \min[G_F, G_S]$$

with  $G_F$  and  $G_S$  a function of  $= (R_p, b, n, u, x)$

- Define and discuss the meaning of the variables  $R_p, b, n, u$  and  $x$ .

[7]

6. For the network in Figure 6.1

- a) Derive the expression for the mean number of outstanding packets in the network.

[10]

- b) Derive the value of the capacity  $C(4)$  for the traffic  $\gamma_{14}$  to split into two routes.

[10]

Notation:

$1/\mu =$  average length of packet = 1000 [bits/packet]

$\gamma_{ij} =$  arrival rate (node  $i$  to node  $j$ ) [packets / s]

$\gamma_{14} = 3$ [kbit/s];  $\gamma_{21} = 2$ [kbit/s];  $\gamma_{34} = 2$ [kbit/s];  $\gamma_{31} = 2$ [kbit/s]

$C(i) = 10$ [kbit/s] for  $i = 1, \dots, 5$

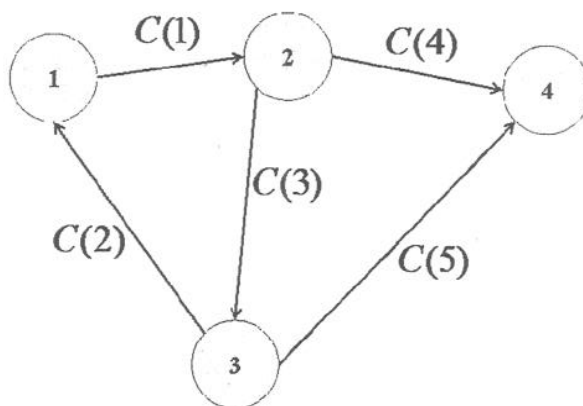


Figure 6.1