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IMPERIAL COLLEGE LONDON

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
EXAMINATIONS 2003

MSc and EEE/ISE PART III/IV: M.Eng., B.Eng. and ACGI

COMMUNICATION NETWORKS

Thursday, 15 May 10:00 am

Time allowed: 3:00 hours

There are FIVE questions on this paper.

Answer FOUR questions.

Corrected Copy

Any special instructions for invigilators and information for candidates are on page 1.

Examiners responsible	First Marker(s) :	J.A. Barria
	Second Marker(s) :	P.J. Beevor

1. (a) For a simplified version of automatic repeat request (*ARQ)* scheme:

Derive a simple expression of the performance of the selective repeat ARQ scheme for $N > 2a + 1$ and $N < 2a + 1$.

Clearly state the meaning of a and N and discuss all assumptions and approximations made. [6]

(b) Derive the performance of a 1-persistent CSMA/CD protocol in terms of channel efficiency. Clearly state the meaning of all variables used and discuss all assumptions made. [6]

(c) For the DQDB operation example presented in *Figure 1.1*:

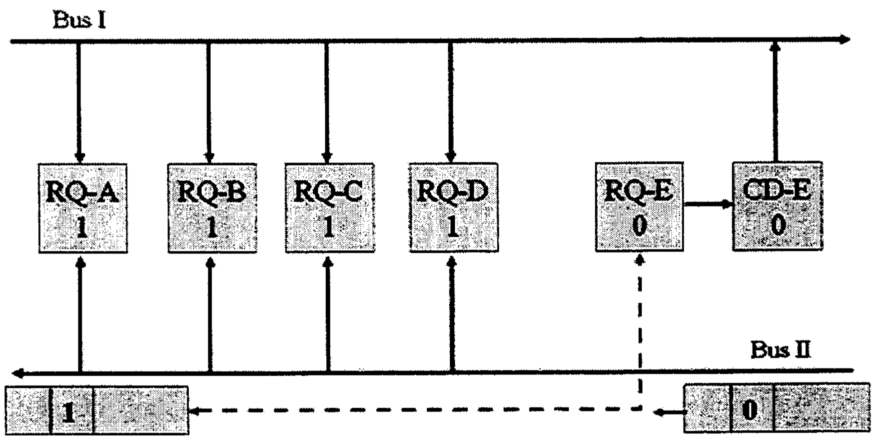

Figure 1.1

There are five stations (A,…, E) attached to the DQDB bus.

Assume that the data transmission is limited to Bus I and that there are no outstanding requests (i.e. to start all nodes have an RQ value of 0.)

Figure 1.1. depicts the case where Station E is requesting a time slot transmission and that this request is placed in Bus II.

Complete all the missing RQ and CD counter values in the following sequence:

1. Station B request for time slot transmission
2. Station C request for time slot transmission
3. A free time slot is available in Bus I for transmission
4. A free time slot is available in Bus I for transmission [8]

2. (a) For a network composed of N nodes and L links, the mean network packet delay T has been defined as:

$$T = \frac{1}{\gamma}\sum_{i=1}^{L}\frac{F_i}{C_i - F_i}. \qquad (2.1)$$

where γ is the total offered load in kbit/s, F_i is the traffic flow in kbit/s carried by link i and C_i be the capacity of that link in kbit/s of link i.

(i) Explain and discuss the importance of Little's theorem. [3]

(ii) Discuss how would you use Little's theorem to derive T. [3]

(b) Consider the network of *Figure 2.1* where *C(i,j)* is the link capacity in kbit/s. Consider also the background traffic demands *Traf(i,j)* with origin node *i* and destination node *j*:

Traf(2,3) = 2 kbit/s
Traf(3,2) = 1 kbit/s
Traf(2,5) = 3 kbit/s
Traf(3,4) = 1 kbit/s
Traf(4,5) = 2 kbit/s
Traf(5,4) = 3 kbit/s

Assuming that all traffic demands *Traf(i,j)* are placed using a minimum hop policy, and that the length of each link of the network is given by:

$$l_{(i,j)} = \frac{C(i,j)}{(C(i,j) - F(i,j))^2} \qquad (2.2)$$

where, *F(i, j)* is the traffic flow in kbit/s carried by link *(i, j)*.

(i) Using node one (1) as your reference node, show step by step all the iterations of the Dijkstra's shortest path algorithm. [14]

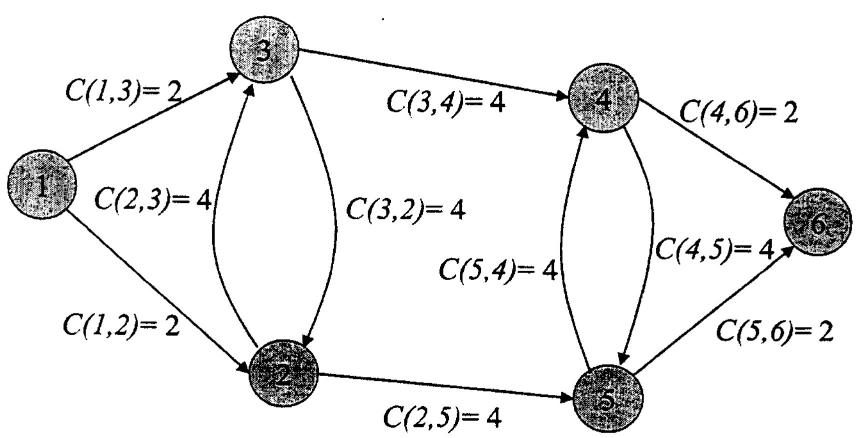

Figure 2.1

3\. (a) For the network of *Figure 3.1*, consider the cost function *D* defined by:

$$D = \sum_{i=1}^{L} \frac{F(i)}{C(i) - F(i)} \qquad (3.1)$$

where, *C(i)* is the capacity of link *i*, *F(i)* is the flow carried by link *i*, and *L* is the maximum number of links in the network.

Assume the value of *C(1) = C(2) = C(3) = C(4) = 20 kbit/s* and *C(5)* = 5 kbit/s.

Calculate the minimum magnitude of offered traffic *R(1, 4)* that will be needed for link *C(5)* to start carrying traffic. [5]

(b) Assume that the network capacity values are *C(1)* = *C(2)* = *C(3)* = *C(4)* = 20 kbit/s and *C(5)* = 10 kbit/s and that the offered load of *R(1,4)* = 10 kbit/s:

Calculate the mean network delay $T = D/\gamma$. [5]

(c) Assume that the cost of deploying capacity in the network is £ 1000 per kbit/s link and that you have the following two options:

(i) Include only *C(1), ..., C(4)* in the solution,
(ii) Solve the problem deploying only *C(5)*.

Suggest the best design option if it is required that the network operates at a point in which $T \leq 0.125$. Discuss your findings. [10]

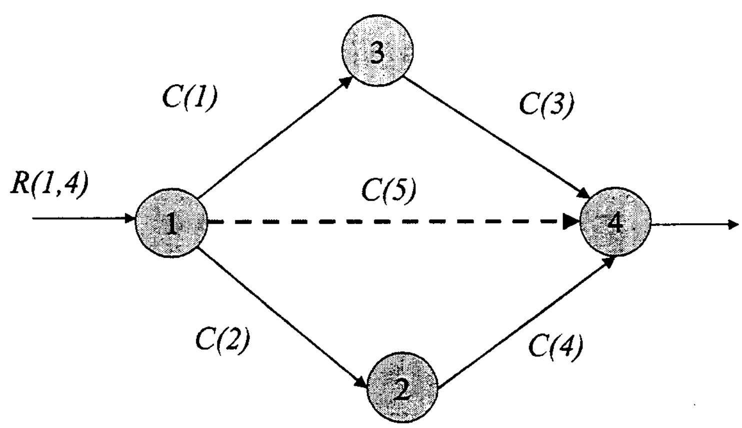

Figure 3.1

4. (a) Network Survivability is an issue of great concern to the telecommunication industry. Define and discuss briefly the following terms:

(i) Traffic restoration,
(ii) Facility restoration,
(iii) Protection switching,
(iv) Re-routing,
(v) Self healing. [10]

(b) ITU-T and the ATM Forum have identified a range of traffic control functions to maintain the quality of ATM connections. In brief:

(i) Describe and discuss the relevance of Connection Traffic Descriptors. [4]

(ii) Describe Generic Cell Rate Algorithms (GCRA). Give an example of a possible implementation of a GCRA. [6]

5. (a) Discuss the relevance and underlying characteristics of UDP and TCP protocols.
Give examples of possible applications. [10]

(b) Discuss the principles of multi-protocol label switching (MPLS) and explain its benefits. [10]