

IMPERIAL COLLEGE LONDON

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
EXAMINATIONS 2014-15

MSc and EEE/EIE PART III/IV: MEng, BEng and ACGI

Corrected Copy

COMMUNICATION NETWORKS

Thursday, 11 December 2:00 pm

Time allowed: 3:00 hours

There are FOUR questions on this paper.

Answer ALL questions.

All questions carry equal marks

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

Examiners responsible First Marker(s) : J.A. Barria
Second Marker(s) : T-K. Kim

Special information for students

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

$$t_i = \frac{1}{\mu C_i - \lambda_i}$$

where,

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

C_i = Transmission speed link i [bits / s]

μC_i = Service rate (link i) [packets / s]

λ_i = Arrival rate (link i) [packets / s]

2. Optimal Routing Problem (ORP)

Min $D(x)$ with respect to $x = \{x_i\}$

where
$$D(x) = \sum_{i=1}^L \frac{x_i}{C(i) - x_i}$$

$C(i)$ = capacity of link i ,

x_i = flow carried by link i ,

L = total number of links in the network.

The Questions

1.

a)

i) Describe and explain the functions carried out by all the GSM elements identified in the first column of Table 1.1.

[5]

ii) For each one of the GSM elements identified in column one of Table 1.1: identify and describe the equivalent mobile IP element.

[3]

Table 1.1

GSM element	GSM element functions	Equivalent Mobile IP element
Home system		
Gateway Mobile Switching Center, or "home MSC", and Home Location Register (HLR)		
Visited System		
Visited Mobile Switching Center, and Visitor Location Register (VLR)		
Mobile Station Roaming Number (MSRN), or "roaming number"		

MSC = Mobile Switching Centre

b) Describe and discuss the following aspects of the link layer of the OSI protocol reference model (PRM):

i) The characteristics of two types of links defined at the link layer of the OSI PRM.

[4]

ii) Three classes of media access control mechanisms known to you that operate at the link layer of the OSI PRM.

[4]

iii) The use of flow control and error control mechanisms that can be deployed at the link layer of the OSI PRM.

[4]

2.

- a) For the network shown in Fig. 2.1, a flow of value R needs to be sent from node A to node B.

The objective function for the system optimal solution is:

$$T = x(1) + x(2)^2$$

where,

$x(1)$ = flow carried in path 1, and

$x(2)$ = flow carried in path 2.

Note also that:

$$R = x(1) + x(2).$$

- i) Derive the optimality condition if flow R is to be split into the two links of the network.

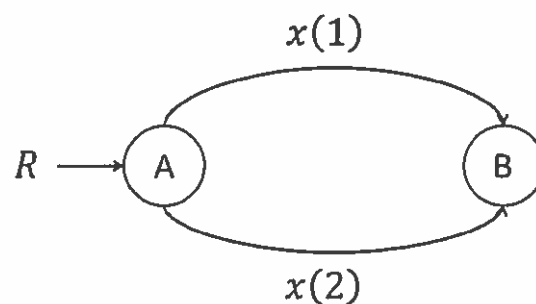
[4]

- ii) Discuss the physical interpretation of the marginal cost of sending part of the flow R on path 1, versus sending part of the flow R on path 2.

[4]

- iii) Derive the optimal value of $x(1)$ and $x(2)$ as a function of R .

[4]



$$R = x(1) + x(2)$$

Figure.2.1

2.

b)

i) Define a measure of utilisation of the sender for the protocol sequence shown in Fig. 2.2. Clearly identify and define parameters L , R and RTT in the figure. [2]

ii) Using Fig. 2.2 derive the utilisation of the sender, in terms of L , R and RTT . [2]

iii) Calculate the utilisation of the sender, using the following information:
Speed of channel connecting sender and receiver is 1 Gbps; the propagation delay on the link is 10 ms, and the segment size is 9000 bits. [2]

iv) Describe and discuss how to enhance the protocol shown in Fig. 2.2, in a way that will result in an improvement of the utilisation of the sender. [2]

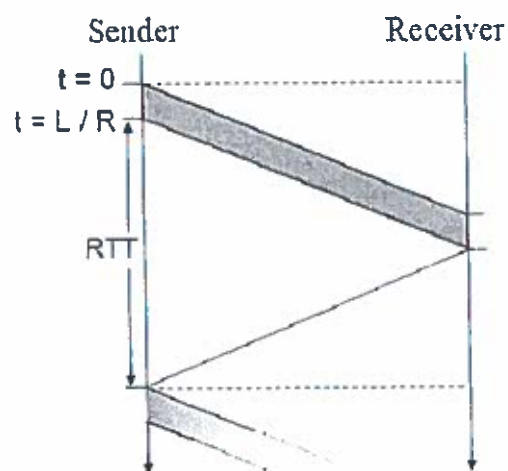


Figure 2.2.

3.

a)

i) Discuss the differences between network-assisted congestion control and end-to-end congestion control.

Which one of these two approaches is taken by the TCP protocol?

[4]

ii) Explain how TCP sessions contend for shared transport resources and avoid congestion.

[3]

iii) Define the concept of fairness in the context of TCP sessions using the same bottleneck link.

[3]

b) In the directed graph shown in Fig. 3.1., $C(i, j)$ is the cost of using link (i, j) .

i) Show step-by-step Dijkstra's algorithm to calculate the shortest path from node 1 to every other vertex in the network.

[10]

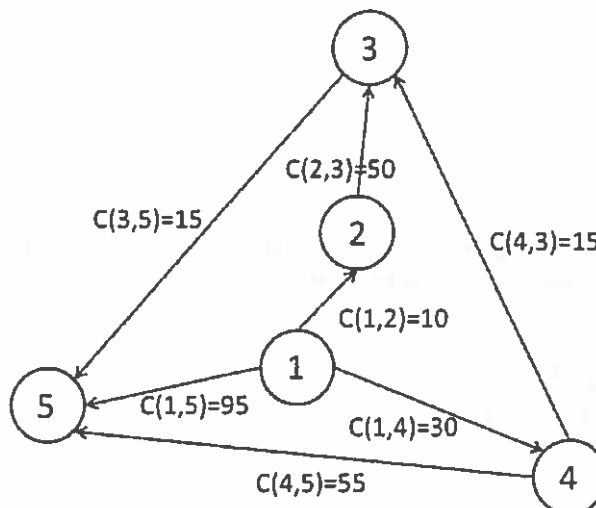


Figure 3.1.

4.

a)

i) Describe the principles behind Multiprotocol Label Switching (MPLS) features and characteristics.

[3]

ii) Sketch the components of a label switching router (LSR) and explain the different functions associated to the control plane and data plane.

[3]

iii) With the help of Fig. 4.1, explain the difference between IP routing and MPLS routing. There are two flows (Origin-1 and Origin-2) and only one destination (Destination-A).

[4]

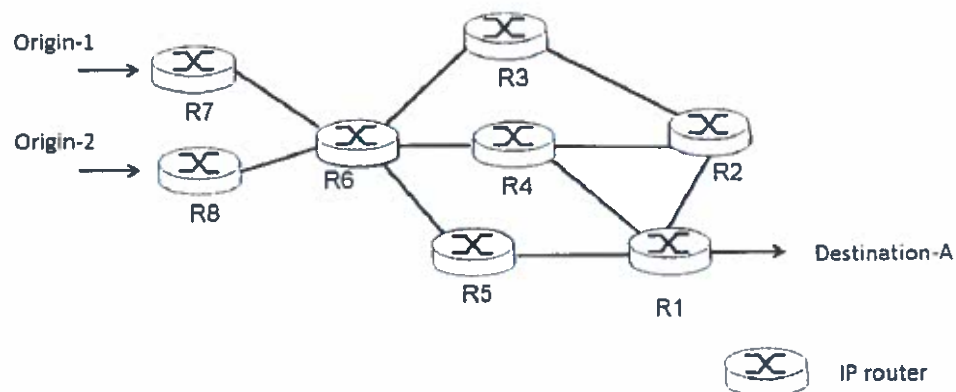


Figure 4.1.

b)

i) Describe two underlying characteristics of wireless networks that make them different to wired LANs (such as Ethernet).

[4]

ii) For the IEEE 802.11 MAC protocol, describe and explain all stages of the Ready to send (RTS) – Clear to send (CTC) exchange.

[6]

