Department of Electrical and Electronic Engineering Examinations | Confidential

Model Answers and Mark Schemes | First Examiner:

Paper Code: EE 3.17 | Second Examiner:

Communication Networks

Question Number etc. in left margin | Mark allocation in right margin

(1) a) IEEE 802.5 (Token Ring)

packet transmission = 1
propagation delay = a

$a < 1$

t_0 = beginning of the transmission of a packet

$t_0 + a$ = leading edge received

$t_0 + 1$ = transmission completed and emit token

$t_0 + 1 + a/N$ = token arrives at next station

$$U = \frac{1}{1 + a/N}$$

$a > 1$

t_0 = beginning of the transmission of a packet

$t_0 + 1$ = transmission completed

$t_0 + a$ = leading edge received and emit token

$t_0 + a + a/N$ = token arrives at next station

$$U = \frac{1}{a + a/N}$$

figures showing above sequences

2(

Department of Electrical and Electronic Engineering Examinations | Confidential

Model Answers and Mark Schemes | First Examiner:

Paper Code: | Second Examiner:

Question Number etc. in left margin | Mark allocation in right margin

Q4 b)

Event at receiver	TCP receiver action
	Delayed ACK. Wait up to 500 ms for next segment. If no next segment send ACK
Arrival of in-order segment with expected sequence nr. One other segment has ACK pending	
	Immediately send duplicate ACK, indicating sequence nr of next expected byte
Arrival of segments that partially or completely fills the gap.	

3/

Department of Electrical and Electronic Engineering Examinations | Confidential

Model Answers and Mark Schemes | First Examiner:

Paper Code: | Second Examiner:

Question Number etc. in left margin | Mark allocation in right margin

Q1 c)

802.11 vs. Ethernet

- Instead of using collision detection 802.11 uses collision avoidance mechanism
- Because the relative high-error rate of wireless channels 802.11 uses a link-layer acknowledgement scheme

802.11

Use of acknowlegment

- When a station receive data: check CRC and wait SIFS and send back an acknowledge
- If sender does not receive the acknowledg within a certain time: retransmit

1. If station senses the channel idle, transmit a frame after DIFS
2. Otherwise station chooses a random backoff
3. When counter reaches zero the station transmits the entire frame then waits for an acknowledgment
4. If an acknowledgent is received, begin CSMA/CA protocol at step 2

Dealing with hidden terminals

In order, to avoid this problem the 802.11 protocol allow a station to use a short request (RTS) control frame and a short clear to send (CTS) control frame to reserve access to channel

Q2 a)

To set TCP time out value, need to consider RTT. But RTT values
too short: premature timeout → unnecessary retransmissions
too long: slow reaction to losses

Sample RTT and average several recent measurements using for example exponential weighted moving average: (influence of the past samples decreases exponentially fast).

$$\text{EstimatedRTT} = (1-\alpha)\,\text{EstimatedRTT} + \alpha\,\text{SampleRTT}$$

Time out interval = EstimatedRTT + safety margin (to account for deviations in EstimatedRTT)

$$\text{DevRTT} = (1-\beta)\,\text{DevRTT} + \beta\,[\text{SampleRTT} - \text{EstimatedRTT}]$$

$$\text{TimeoutInterval} = \text{EstimatedRTT} + \underbrace{4\,\text{DevRTT}}_{\text{safety margin}}$$

Department of Electrical and Electronic Engineering Examinations | Confidential

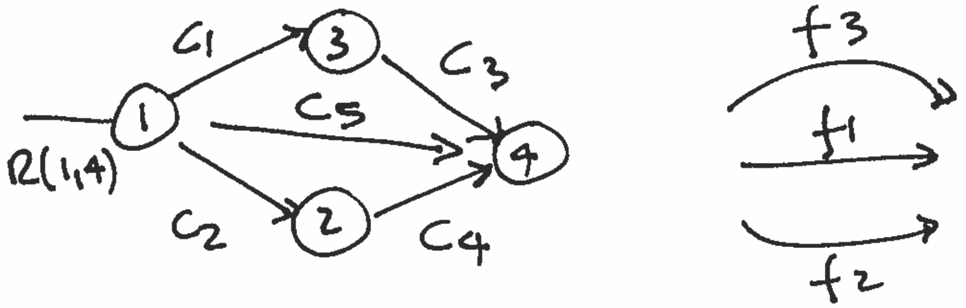
Model Answers and Mark Schemes | First Examiner:

Paper Code: | Second Examiner:

Question Number etc. in left margin | Mark allocation in right margin

Q2 b)

i)



$$f_1 + f_2 + f_3 = R(1,4)$$

$$f_2 = f_3 \longrightarrow f_1 = R - 2f_2,$$

$$\frac{c_5}{(c_5 - f_1)^2} = \frac{2\,c_1}{(c_1 - f_2)^2}$$

ii)

$$\sqrt{c_5}\,(c_1 - f_2) = \sqrt{2c_1}\,(c_5 - f_1)$$

$$\text{if } f_1 = 0 \quad f_2 = \frac{R(1,4)}{2}$$

$$\sqrt{c_5}\left(c_1 - \frac{R}{2}\right) = \sqrt{2c_1}\;c_5$$

$$\frac{(c_1 - R/2)}{\sqrt{2c_1}} = \sqrt{c_5}$$

$$c_5 = \frac{(c_1 - R/2)^2}{2\,c_1}$$

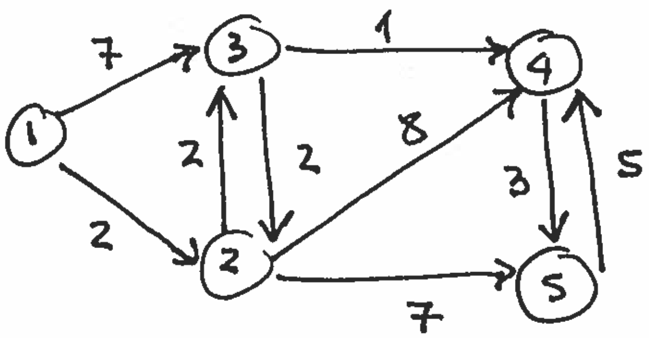
Department of Electrical and Electronic Engineering Examinations | Confidential

Model Answers and Mark Schemes | First Examiner:

Paper Code: | Second Examiner:

Question Number etc. in left margin | Mark allocation in right margin

Q3
a)



I	N	D(3), P(3)	D(2), P(2)	D(4), P(4)	D(5), P(5)
	1	7, 1	2, 1	∞	∞
	1, 2	4, 2		10, 2	9, 2
	1, 2, 3			5, 3	9, 2
	1, 2, 3, 4				8, 4

Department of Electrical and Electronic Engineering Examinations — Confidential

Model Answers and Mark Schemes — First Examiner:

Paper Code: — Second Examiner:

Question Number etc. in left margin — Mark allocation in right margin

Q3 b)

i) Fig a)

$a = RTT$

$b = S/R$

$c = WS/R$

$d = RTT$

Fig b)

e ~~a~~ $= RTT$

f ~~b~~ $= S/R$

h ~~c~~ $= WS/R$

g ~~d~~ $= O/R$

ii) $WS/R > RTT + S/R$ = the server receives an Ack for the first segment before the server completes the transmission

$WS/R < RTT + S/R$ = the server transmit the first window's worth of segments before the server received an Ack for the first segment

iii) For $WS/R > RTT + S/R$

Latency $= 2RTT + O/R$ (from figures)

For $WS/R < RTT + S/R$

Latency $= 2RTT + O/R + (K-1)[S/R + RTT - WS/R]$

RTT = round trip time

O/R = time required to transmit file

K = number of windows of data ($= O/WS$)

S/R = segment arrives every S/R seconds

WS/R = time required to transmit the complete window

Explanations with help of figures

Department of Electrical and Electronic Engineering Examinations | Confidential

Model Answers and Mark Schemes | First Examiner:

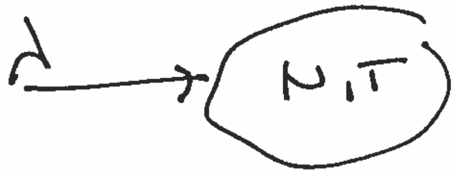
Paper Code: | Second Examiner:

Question Number etc. in left margin | Mark allocation in right margin

Q4 a)

Little's results express the natural idea that crowded systems (large N) are associated with long customer delays (large T). Taking time average of, N, number of customers who arrive in (0,t), number of customers in the system at time t and the time, T, spent in the system by the ith arrival:

$$N = \lambda T$$



The mean network delay in a network of queues can be calculated by first estimating the number of packets in each queue and then adding up all packets in queue:

$$\sum q_i = N = \lambda T$$

where q_i = number of packets in queue i

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

$$\sum \lambda_i t_i = N$$

$$N = \sum_{i=1}^{4} \frac{\lambda_i}{\mu C_i - \lambda_i}$$

Department of Electrical and Electronic Engineering Examinations | Confidential

Model Answers and Mark Schemes | First Examiner:

Paper Code: | Second Examiner:

Question Number etc. in left margin | Mark allocation in right margin

Q4 b)

Providing multiple classes of services
- partition traffic into classes
- Network treats different classes of traffic differently.

1. packet marking is needed for router to distinguish between different classes. Routers will treat packets accordingly.
2. provide protection for one class from others: policing (force source to comply with bandwidth request/allocation.
3. Use resources as efficiently as possible (if allocating fixed bandwidth there will be an inefficient use of bandwidth if flows do not use their allocation)
4. Call Admission: flows declare their needs before being allocated network resources. Network may block call if it cannot meet needs.

Department of Electrical and Electronic Engineering Examinations — Confidential

Model Answers and Mark Schemes — First Examiner:

Paper Code: — Second Examiner:

Question Number etc. in left margin — Mark allocation in right margin

Q4 ii) 5)

Diffserv

- Simpler and more scalable than INTSERV model
  - per flow service is replaced with per aggregate service
  - Complex processing is moved from core of network to the edge
- The Diffserv model allocates resources to a small number of classes of traffic

Edge Routers:

- Per-flow traffic management
- Marks packets as in-profile and out-profile

CORE Routers:

- Per class traffic management
- Buffering and scheduling based on marking at edge
- Preference given to in-profile packet over out-of-profile packets

- Service level Agreement

- Per hop behaviour

Department of Electrical and Electronic Engineering Examinations | Confidential

Model Answers and Mark Schemes | First Examiner:

Paper Code: | Second Examiner:

Question Number etc. in left margin | Mark allocation in right margin

Q4 5) ii)

INTSERV

- Provides specification of a number of service classes
- It also defines how RSVP (reservation protocol) can be used to make reservations for these classes

Mechanism

- Provide the network with flow information (flow spec)
- Ask the network to provide particular services (Admission control)
- Exchange of information which results in resource reservation, and
- Manage packets: packet scheduling and traffic policing

- packet classifiers
- Admission control
- Explicit resources reservation (RSVP)
- packet scheduling