

Q1 (a) Performance of ARQ protocol (backwork)

$$U = \frac{\text{transmission time}}{N_R (\text{time line engaged})}$$

N_R = Expected number of retransmissions

$P^{i-1}(1-P)$ = probability that a transmission will take exactly i attempts

$$N_R = \sum_{i=1}^{\infty} i P^{i-1} (1-P) = \frac{1}{1-P} = \text{Expected number of retransmissions of one frame.}$$

Selective reject ARQ

$$U (P > 2a+1) = 1-P$$

$$U (P < 2a+1) = \frac{P(1-P)}{1-2aP}$$

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

$$U = \text{size of window}$$

Communicator Networks

Question Number etc. in left margin

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Q1

(9)

1-persistent CSMA/CD (best work)

$$A = \binom{N}{1} P^1 (1-P)^{N-1} = NP(1-P)^{N-1}$$

(probability exactly one station attempts transmission in slot)

 $N = \text{no. of stations}$ $P = \text{probability that a station transmits during an available time slot}$

slot = time end to end propagation delay.

mean number of slot per contents

$$\sum_{i=0}^{\infty} iA(1-A)^{i-1} = \frac{1}{A}$$

mean contention interval $(= 2t/A)$ $t = \text{propagation delay}$ channel efficiency $\text{Eff} = \frac{1}{L + 2t/A}$ $L = \text{frame length}$

Q1

(6)

(i) $RQA = 2$; $RQB = 0$, $CDB = 1$; $RQC = 1$; $RQD = 1$; $RQE = 0$, $CDE = 0$ (ii) $RQA = 3$; $RQB = 1$, $CDB = 1$; $RQC = 0$, $CDC = 1$; $RQD = 1$; $RRE = 0$, $CDE = 0$ (iii) $RQA = 2$; $RQB = 1$, $CDB = 0$; $RQC = 0$, $CDC = 0$; $RQD = 0$; $RQE = 0$ (iv) $RQA = 1$; $RQB = 1$; $RQC = 0$, $CDC = 0$; $RQD = 0$; $RQE = 0$

Communication Networks

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Q2
(a)

Little's express the fundamental idea that crowded system (bookmarks)
are associated with long customer delays.

$N(t)$ = number of customers in the system at time t

$x(t)$ = number of customers who arrive in $[0, t]$

T_i = time spent in the system by the i -th arriving customer

- Record the observations from $t=0$ to t and take the time average of the observations then

$$N \Rightarrow T$$

$$N = \lim_{t \rightarrow \infty} N_t \quad ; \quad d_t = \frac{1}{t} \int_0^t x(s) ds$$

$$d = \lim_{t \rightarrow \infty} d_t \quad ; \quad d_t = \frac{x(t)}{t}$$

$$T = \lim_{t \rightarrow \infty} T_t \quad ; \quad T_t = \frac{\sum_{i=1}^t T_i}{t}$$

In the derivation of the Mean network packet delay

Little's result is used:

- at the network level $\quad \therefore T = N = \sum_{i=1}^L d_i t_i$

- at the queue level (representing each one of the links of the network)

$$q_i = d_i t_i$$

MODEL ANSWER and MARKING SCHEME

First Examiner

Paper Code

Second Examiner

Question

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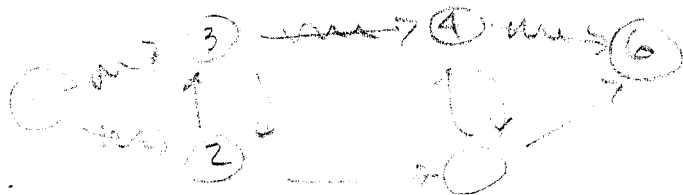
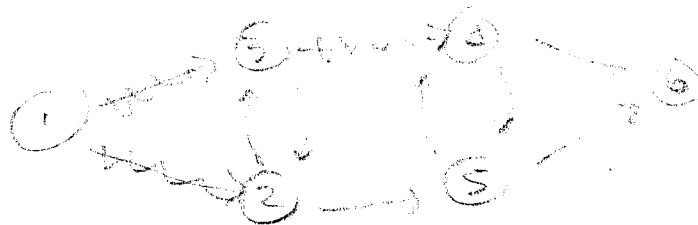
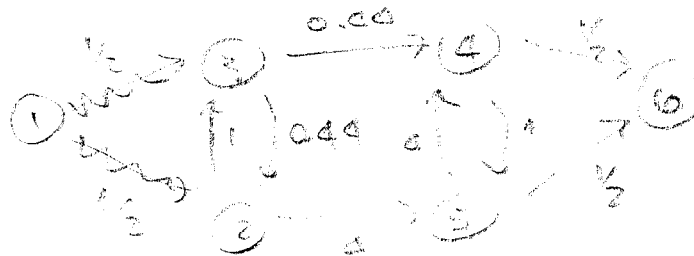
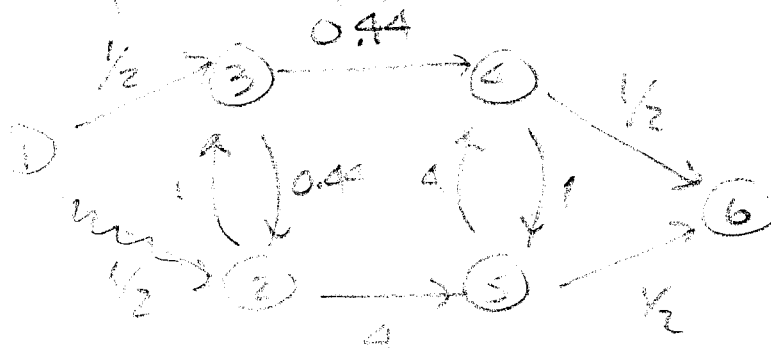
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Q2
(5)

(new computed example)



MODEL ANSWER and MARKING SCHEME

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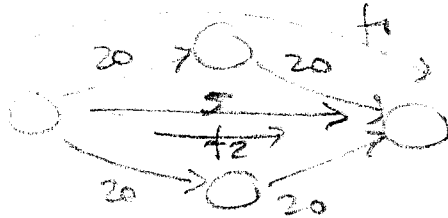
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Q3
(a)

$$\left. \begin{aligned} R &= 2f_1 + f_2 \\ \text{if } f_2 &= 0 \end{aligned} \right\} \Rightarrow f_1 = \frac{R}{2}$$

$$l_1 = \frac{2 \times 20}{(20 - f_1)^2}$$

$$l_2 = \frac{5}{(5 - 0)^2} = \frac{1}{5}$$

$$l_1 > l_2$$

$$\frac{2 \times 20}{(20 - f_1)^2} > \frac{1}{5}$$

$$200 > (20 - f_1)^2$$

$$\sqrt{200} > 20 - f_1$$

$$-5.85 > -f_1 \Rightarrow f_1 > 5.85$$

$$R > 11.71$$

Communication Networks

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Q2
(9)

$$R(1,4) = 10 \text{ kWh/s } 45602 \text{ CAD}$$

$$10 = 2f_1 + 4f_2$$

$$\frac{2 \times 20}{(20 + f_1)^2} - \frac{10}{(10 + f_2)} = \frac{10}{(2f_1 + 4f_2)}$$

$$f_1 = 4.0 \quad \left(f_1 = \frac{\sqrt{10} \cdot 20}{2\sqrt{40} + \sqrt{10}} \right)$$

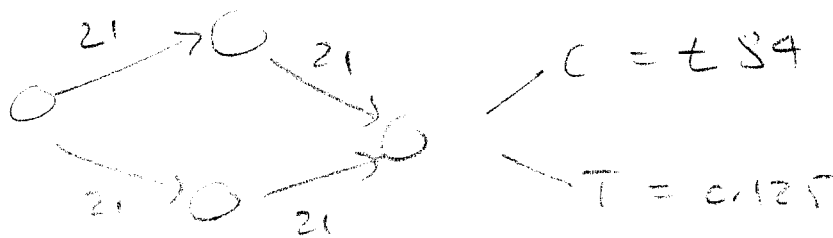
$$f_2 = 2.0$$

$$D = \frac{4.5}{20 - 4} + \frac{2}{10 - 2} = 1.25 \quad T = 0.125$$

Q3
(5)

$$D = 50 \rightarrow C = \pm 50$$

$$T = 0.125$$



Discussion based on reliability aspects

Communication Systems

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Q4

Restoration Categories

(a)

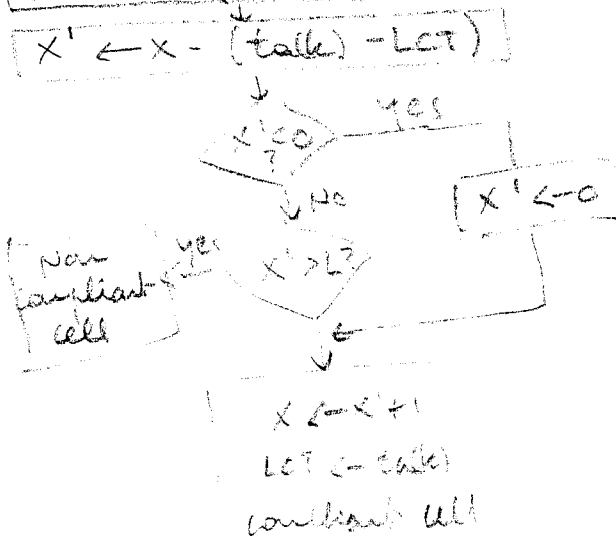
- Traffic restoration: individual calls
- Facility restoration: network facilities e.g. multiplexers, ATM, cross connect syst.
- Protection switching: established pre-assigned replacement connections (no network management function)
- Re-routing: establishment or replacement of connection (by a network management control connection)
- Self-healing: establishment of a replacement connection by network (no network management control function)

(b)

(i) Describe and discuss:

- PRB: Peak Cell Rate
- SCR: Sustained Variation Tolerance
- SCR: Sustainable Cell Rate
- MPT: Maximum Burst Tolerance

(ii) Continuous-state leaky bucket Algorithm

Arrival of a cell at time $t_a(k)$ 

X = value of the leaky bucket counter

X' = aux. variable

LCT = last compliance time

Pde at $t_a(1)$ $X=0$ and $LCT = t_a(1)$

Communication Systems

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Q5

UDP is an unreliable connectionless transport layer protocol

It is a simple extension to IP that provides

- Demultiplexing of IP packets
- Error checking of data, and
- Multiple applications in the host

TCP is a connection oriented data stream service transport layer protocol

TCP provides

- Full duplex reliable, sequenced, flow-controlled
- A recovery mechanism for out-of-order packets, duplicate packets, lost packets, corrupt packets
- A flow and congestion control mechanism
- Support for multiple application processes in the same end system

MPLS

- Integrates layer 2 switching with layer 3 routing
- A key feature is the separation of the control (plane) and the forwarding data (plane) in a label switching router.
- MPLS focus on IPv4 and IPv6
- MPLS operate with multiple layer 2 technologies e.g. ATM, FR, VLL and Ethernet
- Improve forwarding performance (using simplified look up process)
- Improve scalability (using label stacking and merging)
- Provide traffic engineering (via explicit efficient routing)