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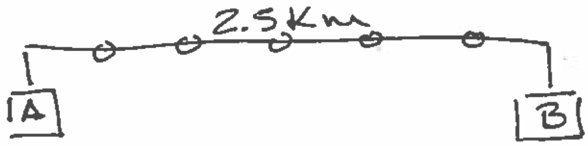
Model Answers and Mark Schemes First Examiner:

Paper Code: EE3-17 Second Examiner:

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

1a)



2

$$T_p = \frac{l}{v} = \frac{2.5\times10^3}{2\times10^8} = 12.5\mu s$$

$2T_p = 25\mu s$ 2

repeaters delay $= 5\times 2.5\mu s = \frac{25}{2}\mu s$

repeat. round trips $= 25\mu s$

The total worst-case time is $50\mu s$ 2

1b)

1) $T_p = 5\times10^{-6}$ s a) $a = \frac{5\times10^{-6}}{1} = 5\times10^{-6} \to 1+2a\sim1$

b) $a = 5\times10^{-3} \longrightarrow 1+2a\sim1$

hence for both a) & b) $U=1$ 2

2) $T_p = 1\times10^{-3}$ s a) $a = 1\times10^{-3} \to 1+2a\sim1 \to U=1$

b) $a = 1 \to 1+2a>1 \to U = \frac{1}{1+2} = 0.\dot{3}$ 3

3) $T_p = 0.1$ s a) $a = \frac{0.1}{1} = 0.1 \to 1+2a>1 \to U = \frac{1}{1.2} = 5/6$ 3

b) $a = 100 \to 1+2a>1$

$U = \frac{1}{1+200} =$

Discussion
- short links with $a<1$ are not affected 2
- Longer terrestrial links the link utilization is higher for low bit rate but falls off significantly as bit rate increases 2
- link utilization is poor for satellite links even at low bit rates. 2

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2a p = probability that the transmission of a single bit is in error.

A frame is correctly received if there is no bit in error. That is m_f bits are transmitted without error.

The probability that a single bit is not in error is $(1-p)$ so $1 - P_f = (1-p)^{m_f}$ 3

$P_f = (0.99, 0.905, 0.368)$ for $p = (10^{-6}, 10^{-5}, 10^{-4})$ 3

+ discussion

2b) i) y = probability of packet drop

x = Average queue length 2

ii) Two thresholds are defined min_{th} and max_{th}. When the average queue length is below min_{th} no arriving packets are dropped. When the queue length is between min_{th} and max_{th} packets are dropped with an increasing probability as the average queue length increases. When the queue length exceeds max_{th} any arriving packet is dropped. 3

iii) RED attempts to provide equitable access to a FIFO system. A dropped packet provides feedback to the source. If a source transmit at a higher rate than others that source will suffer from a higher packet-dropping rate. This will result in a more uniform transmission rate among the sources. 4

iv) RIO = two thresholds T1 & T2 for each queue

- if queue length $L < T1$ – no packets are dropped
- when $T1 < L < T2$ only out packets are randomly dropped
- when $L > T2$ both in and out packets are randomly dropped, but out packet are dropped at a higher rate.

RIO provides early detection with QoS consideration 5

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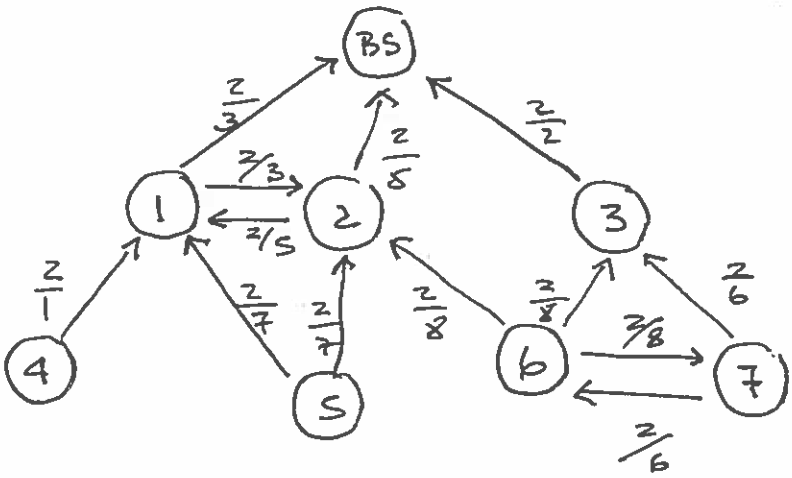
3a)

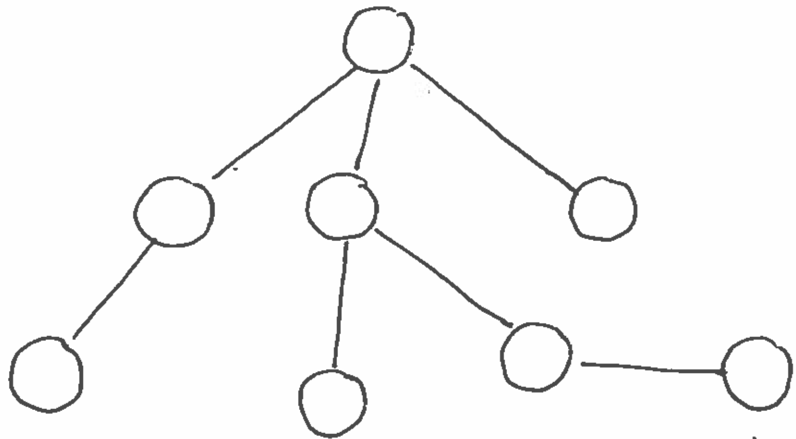
	Total lenght	ID	MF	Fragment offset	
original packet	1504	x	0	0	
Fragment 1	572	x	1	0	2
Fragment 2	572	x	1	69	2
Fragment 3	400	x	0	138	2

3b) i)



4

ii)



2

- clearly show all the iterations of Dijkstra algorithm 4

iii) - Three messages 2

- show clearly method to solve problem and iterations 2

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4a) i) axis y = congestion window
x = Round trip times 2

ii) Identify, describe and discuss the following phases:

A = Congestion avoidance
B = Time out
C = slow start
D = Threshold. 2

4b) i) $EC = \int_0^\infty f(y)\, t^2 dy + \int_0^\infty f(y)\, y^2 dy + \int_0^\infty 2ty\, dy$

$t^2 + E[y^2] + 2t\,E[y] = (t+\mu)^2 + \sigma^2$

$(\mathrm{Var}(y) = \sigma^2 = E[y^2] - [E(y)]^2) \qquad \Rightarrow \quad t = -\mu$ 5

ii) Route 1 is on average faster ($\mu_1 < \mu_2$) and more reliable ($\sigma_1 < \sigma_2$).
However as the departure time gets close to the target arrival time route 2 will give a higher probability of arriving on time 5

iii) Route 1 $\mu_1 = 14$ $\sigma_1 = 1$
Route 2 $\mu_2 = 15$ $\sigma_2 = 4$

$EC_1 = \sigma_1^2 = 1$ — select route 1.

$EC_2 = \sigma_2^2 = 16$

since we can choose $t_i = -\mu_i$ 4

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4a iii) A) Congestion avoidance: Additive increase, resulting in increasing of congestion window by 1 MSS every RTT

B) Time out: The threshold is set to half previous congestion window. The congestion window is set to 1 MSS and enter slow start phase.

C) Slow start: The congestion window is increased such that the resulting congestion window is doubled every RTT. If the congestion window is greater than the threshold, enter congestion avoidance phase.

D) Threshold: determines the window size at which slow start will end and congestion avoidance will begin 2