SOLUTION ASSIGNMENT-01 (BCS 5A & 5C)

PART-01

REVIEW QUESTIONS

R13.

a) 2 users can be supported because each user requires half of the link bandwidth.

b) Since each user requires 1Mbps when transmitting, if two or fewer users transmit simultaneously, a maximum of 2Mbps will be required. Since the available bandwidth of the shared link is 2Mbps, there will be no queuing delay before the link. Whereas, if three users transmit simultaneously, the bandwidth required will be 3Mbps which is more than the available bandwidth of the shared link. In this case, there will be queuing delay before the link.

c) Probability that a given user is transmitting = 0.2

d) Probability that all three users are transmitting simultaneously = $\binom{3}{3} p^3 (1-p)^{3-3}$ = $(0.2)^3$ = 0.008. Since the queue grows when all the users are transmitting, the fraction of time during which the queue grows (which is equal to the probability that all three users are transmitting simultaneously) is 0.008.

R16.

The delay components are processing delays, transmission delays, propagation delays, and queuing delays. All of these delays are fixed, except for the queuing delays, which are variable.

R18.

(1) Propagation Delay = d/s = 2500 km/ 2.5×10^8 m/s = 2,500,000/2.5×10^8 m/s = 0.01 s = 10 ms

Transmission Delay = L/R = (1000×8) bits/2 Mbps = (1000×8) bits/2×10^6 bps = 4 ms

Total Delay = 10 + 4 = 14 ms.

(2) d/s + L/R

(3) No, it doesn't depend on packet length

(4) No, it doesn't depend on transmission rate

R19.

(1) Throughput = min(R1, R2, R3) = min(500, 2000, 1000) kbps = 500 kbps.

(2) Time = bits/throughput = (8 * 4,000,000) bits/500,000 bps = 64 seconds

(3) Now, R2 = 100 kbps

Throughput = min(R1, R2, R3) = min(500, 100, 1000) kbps = 100 kbps

Time = bits/throughput = (8 * 4,000,000) bits/100,000 bps = 320 seconds

PROBLEMS

Problem 3.

(a) A circuit-switched network would be well suited to the application, because the application involves long sessions with predictable smooth bandwidth requirements. Since the transmission rate is known and not bursty, bandwidth can be reserved for each application session without significant waste. In addition, the overhead costs of setting up and tearing down connections are amortized over the lengthy duration of a typical application session.

(b) In the worst case, all the applications simultaneously transmit over one or more network links. However, since each link has sufficient bandwidth to handle the sum of all of the applications' data rates, no congestion (very little queuing) will occur. Given such generous link capacities, the network does not need congestion control mechanisms.

Problem 6.

a) $d_{prop} = m/s$ seconds.

b) $d_{trans} = L/R$ seconds.

c) $d_{end-to-end} = (m/s + L/R)$ seconds.

d) The bit is just leaving Host A.

e) The first bit is in the link and has not reached Host B.

f) The first bit has reached Host B.

g) We want $\boldsymbol{m = \frac{L}{R}s = \frac{1500\times8}{10\times10^6}(2.5\times10^8) = 3\times10^5 = 300}$ km.

Problem 31.

a) Time to send message from source host to first packet switch $= \frac{\mathbf{10^6}}{\mathbf{5\times10^6}} = \mathbf{0.2}$sec With store-and-forward switching, the total time to move message from source host to destination host $= \mathbf{0.2\mathit{sec} \times 3\mathit{hops} = 0.6\mathit{sec}}$

b) Time to send 1st packet from source host to first packet switch = $\frac{1\times10^4}{2\times10^6}$ sec $= 5\ m\sec$. Time at which 2nd packet is received at the first switch = time at which 1st packet is received at the second switch = $2\times 5m\sec = 10\ m\sec$

c) Time at which 1st packet is received at the destination host = $5\ m\sec \times 3\ hops = 15\ m\sec$. After this, every 5msec one packet will be received; thus time at which last (800th) packet is received = $15\ m\sec + 799 * 5m\sec = 4.01\sec$. It can be seen that delay in using message segmentation is significantly less (almost 1/3rd).

d)

i. Without message segmentation, if bit errors are not tolerated, if there is a single bit error, the whole message has to be retransmitted (rather than a single packet).
ii. Without message segmentation, huge packets (containing HD videos, for example) are sent into the network. Routers have to accommodate these huge packets. Smaller packets have to queue behind enormous packets and suffer unfair delays.

e)

i. Packets have to be put in sequence at the destination.
ii. Message segmentation results in many smaller packets. Since header size is usually the same for all packets regardless of their size, with message segmentation the total amount of header bytes is more.

PART-02

Question 1

(1) Sum of all links = 16 + 20 + 10 + 10 = 56
(2) If all connections are full, the request will be blocked. No, the request will not be accepted.
(3) Every call must go two hops clockwise.
    (a) From A → C path is AB & BC
    (b) From B → D path is BC & CD
    (c) From C → A path is CD & DA
    (d) From D → B path is DA & AB

    Since AB can carry at most 16 and CD at most 10, the maximum total is 16 + 10 = 26.

(4) Requested calls = 11 (for A→C) + 15 (for B→D) = 26. Since 26 ≤ 26 (from part 3), all can be routed within link capacities. Yes, the network can support these 26 calls.

Question 2

(1) Maximum end-to-end throughput per pair = min(Rs, R/4, Rc) = min(30, 400/4=100, 90) = 30 Mbps
(2) Bottleneck links are the links with the minimum value. In this case the Server Links (Rs).
(3) Utilization (each Rs) = throughput / capacity = 30 / 30 = 1 or **100%**
(4) Utilization (each Rc) = 30 / 90 = 0.33 or **33.33%**
(5) Shared middle-link utilization (R) = (4 × 30) / 400 = 0.3 or **30%**

Question 3

1) When circuit switching is used, at most 6 users can be supported. This is because each circuit-switched user must be allocated its 25 Mbps bandwidth, and there is 150 Mbps of link capacity that can be allocated. 150/25 = **6 users**

II) The probability that a given (specific) user is busy transmitting, which we'll denote p, is just the fraction of time it is transmitting, i.e. 0.2. The probability that one specific other user is not busy is (1-p), and so the probability that all of the other N_{ps}-1 users are not transmitting is $(1-p)^{Nps}$-1. Thus the probability that one specific user is transmitting and the remaining users are not transmitting is $p*(1-p)^{Nps}$-1, which has the numerical value = $0.20*0.80^{(11-1)}$ = **0.021**

III) This user will be transmitting at a rate of 25 Mbps over the 150 Mbps link, using a fraction 0.17 of the link's capacity when busy. 25/150 = 0.1666666….. = 1/6th = **0.17** fraction of the link's capacity.

IV) The probability that 3 specific users of the total 11 users are transmitting and the other 8 users are idle is $p^3(1-p)^8$. Thus the probability that any 3 of the 11 users are busy is choose (11, 3)* $p^3(1-p)^8$, where choose(11, 3) is the (11, 3) coefficient of the binomial distribution). The numerical value of this probability =choose (11,3) * $p^3(1-p)^8$ = (11!/(3!*8!)) * 0.20^3 $(1 - 0.2)^8$ = **0.22**