Home Work - 1

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Problem : 6 :

(a) Here,

the distance between host A and B is m meters

propagation speed $= s \ ms^{-1}$

So, propagation delay $= \dfrac{\text{distance}}{\text{Propagation speed}} = \dfrac{m}{s}$

$\therefore d_{prop} = \dfrac{m}{s}$ secs

(b)

packet size = L bits

transmission rate = R bps

$\therefore$ transmission time/delay $= \dfrac{\text{size}}{\text{trans. rate}}$

$\therefore d_{trans} = \dfrac{L}{R}$ s

(c) Ignoring processing and queuing delays

the end to end delay, $d_{end-end} = d_{prop} + d_{trans}$

$= \left(\dfrac{m}{s} + \dfrac{L}{R}\right)$ s

(d) At $t = d_{trans}$ the last bit of the packet will just be leaving Host A.

(e) If $d_{prop}$ is greater than $d_{trans}$ then the first bit of packet will be in between Host A and Host B.

(f) If the $d_{prop}$ is less than $d_{trans}$ then the first bit will have reached the Host B at $t = d_{trans}$.

(g) here,

$$s = 2.5 \times 10^8$$

$$L = 1500 \text{ bytes} = 1500 \times 8 \text{ bits} = 12000 \text{ bits}$$

$$R = 10 \text{ Mbps} = 10 \times 10^6 \text{ bps} = 10^7 \text{ bps}$$

Now,

$$d_{trans} = \frac{L}{R} \quad \text{and} \quad d_{prop} = \frac{m}{s}$$

Now, $d_{trans} = d_{prop}$

$$\Rightarrow \frac{L}{R} = \frac{m}{s}$$

$$\Rightarrow m = \frac{L}{R} \times s = \frac{12000}{10^7} \times 2.5 \times 10^8$$

$$= 3 \times 10^5 \text{ m}$$

$$= 3 \times 10^3 \text{ Km}$$

$$= 3000 \text{ Km}$$

## problem : 7 :

Host A sends to Host B when a full packet of 56 byte arrives and Host B decodes to analog after a full packet is received.

The delay requires to convert analog voice to digital bits for a packet $= \frac{56 \times 8}{64 \times 10^3}$ sec

$= 7 \times 10^{-3}$ ~~sec~~

$= 7$ msec

Transmission delay for a packet $= \frac{56 \times 8}{10 \times 10^6}$ s

$= 44.8 \times 10^{-6}$ s

$= 44.8\ \mu s$

propagation delay $= 10$ ms

So, the time required for bit creation at Host A until bit decode at Host B

$= (7\text{ms} + 44.8\ \mu\text{s} + 10\text{ms})$

$= 17.0448$ ms

## Problem: 8:

(a) The link bandwidth = 10 Mbps

each user requires = 200 Kbps

So, if circuit switching is used

$$\text{user count} = \frac{10 \times 10^6}{200 \times 10^3} = 50$$

(b) each user transmit 10 percent of the time. So, the probability is $p = 0.10$

(c) the probability of a user transmitting

$$p = 0.1$$

So, the probability of a user not transmitting

$$p' = 1 - 0.1 = 0.9$$

we can select $n$ user from 120 users in ${}^{120}C_n$ way.

So, the probability of exactly $n$ users transmitting $= {}^{120}C_n \, p^n \cdot p'^{120-n}$

$$= {}^{120}C_n \, (0.1)^n \cdot (0.9)^{120-n}$$

8(d)

$p = 0.1$

$p' = 0.9$

From (c) the probability of exactly $n$ users transmitting $= {}^{120}C_n \, p^n . p'^{\,120-n}$

Now, For the probability of 51 users or more transmitting it will be

$$\sum_{n=51}^{120} {}^{120}C_n \, p^n . p'^{\,120-n}$$

Problem: 9:

(a) Link bandwidth $=$ ~~1 Mbps~~ 1 Gbps

$= 10^9$ bps

user data rate $=$ 100 Kbps

$= 10^5$ bps

$\therefore$ The maximum number of users for circuit switching $= \dfrac{10^9}{10^5} = 10000$

(b) The probability of N users sending data $= {}^{M}C_N \, p^N . (1-p)^{M-N}$

So, the probability that more than N users are sending data $= \sum_{n=N+1}^{M} {}^{M}C_n \, p^n . (1-P)^{M-n}$

Problem : 10 :

delay of 1st link $d_1 = d_1 prop + d_1 trans + d proc$

$$= \frac{d_1}{S_1} + \frac{L}{R_1} + dproc$$

delay of 2nd link, $d_2 = d_2 prop + d_2 trans + d proc$

$$= \frac{d_2}{S_2} + \frac{L}{R_2} + dproc$$

delay of 3rd link, $d_3 = d_3 prop + d_3 trans$

$$= \frac{d_3}{S_3} + \frac{L}{R_3}$$

dproc, that means processing delay will only happen at the end of 1st and 2nd link.

So, the total end-end delay for the packet

$$= d_1 + d_2 + d_3 = \frac{d_1}{S_1} + \frac{L}{R_1} + dproc + \frac{d_2}{S_2} + \frac{L}{R_2} + dproc +$$

$$\frac{d_3}{S_3} + \frac{L}{R_3}$$

$$= \frac{d_1}{S_1} + \frac{d_2}{S_2} + \frac{d_3}{S_3} + \frac{L}{R_1} + \frac{L}{R_2} + \frac{L}{R_3} + 2\,dproc$$

(b) $S_1 = S_2 = S_3 = 2.5 \times 10^8$

$L_x = 1500$ bytes $= 12000$ bits

$R_1 = R_2 = R_3 = 2.5$ Mbps $= 2.5 \times 10^6$ bps

$d_1 = 5000 \times 10^3 m$, $d_2 = 4000 \times 10^3 m$

$d_3 = 1000 \times 10^3 m$

$d proc = 3 \times 10^{-3}$ sec

So, the end-end delay.

$$= \frac{5000\times10^3}{2.5\times10^8} + \frac{4000\times10^3}{2.5\times10^8} + \frac{1000\times10^3}{2.5\times10^8} + \frac{12000}{2.5\times10^6}\times 3 + \frac{2\times3}{10}$$

$$= 0.0604\ s = 60.4\ msec$$

<u>Problem : 12 :</u>

A packet has to wait until 4.5 packets are transmitted.

So, the queuing time $= \frac{4.5\times1500\times8}{2.5\times10^6}$ s

$= 21.6$ msec

For the general scenario $n$ packet are already in the queue. So, these packets have to transmit first along with the $(L-x)$ bits of another packet.

So, queuing time $= n\frac{L}{R} + \frac{(L-x)}{R}$

**Problem : 15 :** From little's theorem

$$N = a \cdot d$$

For simplified queuing system

$$N = \frac{a}{\mu - a}$$

$$\therefore d = \frac{1}{\mu - a}$$

So, total delay $= \frac{1}{\mu - a}$

**Problem : 16 :** The total number of packets

$$N = 100 + 1 = 101$$

$d =$ queuing time + transmission time

$= 20 \text{ msec} + \frac{1}{100} s$

$= 30 \text{ msec}$

Now, little's formula

$$N = a \cdot d$$

$$\therefore a = \frac{N}{d} = \frac{101}{30} = 3.37 \text{ msec}^{-1}$$

## Problem : 23 :

(a) first link is the bottleneck link with rate $R_s$ bps.

So, time to transmit one packet $= \frac{L}{R_s}$

which is the time delay between last bit of first package and last bit of second package

(b) First package will take $\frac{L}{R_s} + \frac{L}{R_c}$ + dprop time to reach the end of second link. But it will take $\frac{2L}{R_s}$ + dprop time for the second packet to reach the input queue and as $R_s > R_c$ so, there must be queuing happen for the second packet.

If we send the second packet T seconds later, we will ensure that there is no queuing delay then

$$\frac{2L}{R_s} + d_{prop} + T \geq \frac{L}{R_s} + \frac{L}{R_c} + d_{prop}$$

$$T >= \frac{L}{R_c} - \frac{L}{R_s}$$

## Problem: 25:

(a) $$d_{prop} = \frac{20000 \times 10^3}{2.5 \times 10^8} = 0.08\,s$$

$\therefore R \cdot d_{prop} = 5 \times 10^6 \times 0.08 = 4 \times 10^5$ bits

(b) maximum number of bits in a link at a time $= R \cdot d_{prop} = 4 \times 10^5$ bits

(c) The bandwidth-delay product of a link is the maximum number of bits that can be in the link.

(d) the width of a bit $=$ length of link $/ R \cdot d_{prop}$

$= 20000 \times 10^3 / 4 \times 10^5$

$= 50\,m.$

So, it's not longer than football field as football field is 91 meter long.

(e) The width of a bit $= \frac{S}{R}$

Problem : 29 :

(a) Geostationary satellites are approximatly 36 000 Km away from earth surface.

$\therefore$ The propagation delay $= \frac{36000 \times 10^3}{2.4 \times 10^8}$ s

$= 150$ msec

(b) $R \cdot d_{prop} = 10 \times 10^6 \times 150 \times 10^{-3}$

$= 1.5 \times 10^6$ bits

(c) The satellite takes a photo in every minute. For continous transmission the photo need to be large enough to sent through the channel in 1 minute.

So, the minimum size $=$ ~~$60 \times 10^6$~~ $= 60 \times 10 \times 10^6$

$= 6 \times 10^8$ bits

problem: 31:

(a) message size = $10^6$ bits

link bandwidth = 5 Mbps

∴ time to reach first packet switch = $\frac{10^6}{5\times10^6}$ s

= 0.2 s

∴ time to reach destination = 3 × 0.2 s

= 0.6 s

(b) The first packet is $10^4$ bits long.

So, time to reach first switch = $\frac{10^4}{5\times10^6}$ = 2 msec

The second packet will reach first switch when the first packet reaches second switch.

So, the time will be 2 × 2 = 4 msec

(c) The first packet will reach the destination in 3 × 2 = 6 msec and after that every 2 msec interval one new packet will arrive at the destination.

So, the time = (6 + 99 × 2) = 204 msec

= 0.204 s

which is much shorter than without message segment transmission.

Problem : 33 :

There are $\frac{F}{S}$ packet and each packet is $S+80$ bits. As there are 3 links first packet will take $\frac{S+80}{R} \times 3$ s time to reach desitination. It will take another $(\frac{F}{S}-1) \times \frac{S+80}{R}$ s for the rest of the packet to reach.

So, total delay $= (\frac{F}{S}-1+3) \times \frac{S+80}{R}$

$$= \left(\frac{F}{S}+2\right) \frac{S+80}{R}$$

Now,

$$\frac{d}{ds}\left\{\left(\frac{F}{S}+2\right) \cdot \frac{S+80}{R}\right\}$$

$$= \left(\frac{S+80}{R}\right) \cdot -\frac{F}{S^2} + \frac{1}{R} \cdot \left(\frac{F}{S}+2\right)$$

$$= -\frac{(S+80)F}{RS^2} + \frac{F+2S}{RS}$$

$$= \frac{-SF-80F+SF+2S^2}{RS^2}$$

$$= \frac{2S^2-80F}{RS^2}$$

For minimum $\frac{2S^2-80F}{RS^2} = 0$

$\therefore S = \sqrt{40F}$

(d) The other reasons are

(1) If 1bit error occurs then we will again have to resend the whole file if without segmentation is used but in message segmentation only sending the packet will do the job.

(2) without segmentation we will have to sent huge packets to the router which will cause greater queuing time.

(e) (1) Total number of header bits increase

(2) Packets need to be put in sequence.