Homework #1 : [Ch.1] Tu Lam

(CS 372)

1. a) Propagation delay (d_{prop}) can be express as :

Answer : $\boxed{d_{prop} = \frac{m}{s} \text{ sec}}$

b) Transmission time of packet can be express as :

Answer : $\boxed{d_{trans} = \frac{L}{R} \text{ sec}}$

c) Ignore processing & queuing delays, the expression for end-to-end delay can be written as :

Answer : $d_{end\text{-}to\text{-}end} = \boxed{d_{prop} + d_{trans} \Rightarrow \frac{m}{s} + \frac{L}{R} \text{ sec}}$

d) Host A → $t=0$, $t = d_{trans}$; $L \rightarrow ?$ $d_{trans} = \frac{L}{R}$ ➡ Answer : $\boxed{\text{As } t = d_{trans}, \text{ the last bit of the packet is just leaving Host A.}}$

e) If $d_{prop} > d_{trans}$, at $t = d_{trans}$ } Answer : $\boxed{\text{The first bit has not reach Host B}}$ mean it's still in the link

$d_{prop} \rightarrow \frac{m}{s}$ (m ← distance, s ← speed); $d_{trans} \rightarrow \frac{L}{R}$ (L ← Packet length, R ← trans. rate)

f) $d_{prop} < d_{trans}$, this means that at $t = d_{trans}$ } Answer : $\boxed{\text{The first bit has already arrive at Host B}}$

g) * $s = 2.5 \cdot 10^{8} \frac{m}{s}$ $R = 56$ kbps → $56 \text{ kbps} \cdot \frac{1000 \text{ bps}}{1 \text{ kbps}} = 56{,}000$ bps

$L = 120$ bits $m = ?$

$\frac{m}{s} = \frac{L}{R} \Rightarrow \frac{m}{2.5 \cdot 10^{8} \frac{m}{s}} = \frac{120 \text{ bits}}{56{,}000 \text{ bps}} = \frac{120 \text{ b}}{56{,}000 \text{ bps}} \cdot (2.5 \cdot 10^{8} \frac{m}{s})$

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

Answer : $\boxed{m = 5.4 \times 10^{5} \text{ m}}$

2. * Packet-Switched Network ➡ Host A ⟶ Host B

$a = 64$ kbps

* $L = 56 \text{ byte} \cdot \frac{8 \text{ bits}}{1 \text{ byte}} = 448$ bits
* $R = 2$ Mbps → $2 \text{ Mbps} \cdot \frac{1 \cdot 10^{6} \text{ bps}}{1 \text{ Mbps}} = 2 \cdot 10^{6}$ bps
* $d_{prop} = 10 \text{ ms} \cdot \frac{1 \text{ s}}{1000 \text{ ms}} = 0.01$ sec
* Convert $= 64 \text{ kbps} \cdot \frac{1000 \text{ bps}}{1 \text{ kbps}} = 64{,}000$ bps

Total delay $= d_{creation} + d_{trans} + d_{prop}$

d_{prop} → 0.01 sec

* $d_{creation} = \frac{448 \text{ bits}}{64{,}000 \text{ bps}} = 0.007$ sec
* $d_{trans} = \frac{L}{R} = \frac{448 \text{ bits}}{2 \cdot 10^{6} \text{ bps}} = 2.24 \cdot 10^{-4}$ sec

Answer : $\boxed{\text{total delay} = 0.017224 \text{ sec}}$

3. * Shared 3 Mbps link   * Each user can transmit 10% of the time

* Require 150 kbps when transmit

a) Circuit Switch $\longrightarrow$ $\frac{\text{Link rate}}{\text{Require rate}} = \frac{3 \cdot 10^6 \text{ bps}}{150{,}000 \text{ bps}} = 20$

Answer : $\boxed{20 \text{ users}}$

b) Packet - Switch $\longrightarrow$ Since there is 10% chance of being transmit, $p = \frac{1}{10}$ or 0.1

probability

Answer : $\boxed{p = \frac{1}{10}}$

c) $P_N^k = \binom{k}{N} p^k (1-p)^{N-k}$

k = 120 users

$P_N^{120} = \left(\frac{N!}{120!(N-120!)}\right) p^{120} (1-p)^{N-120}$ ($p = \frac{1}{10}$) $\Rightarrow$ Answer : $\boxed{P_N^{120} = \left(\frac{N!}{120!(N-120)!}\right) \cdot \left(\frac{1}{10}\right)^{120} \left(\frac{9}{10}\right)^{N-120}}$

d) k = 21 or more?

$P_N^{120} = \left(\frac{N!}{120!(N-120)!}\right) \left(\frac{1}{10}\right)^{120} \left(\frac{9}{10}\right)^{120-n}$

$P(X \geq 21) = 1 - P(x < 21)$

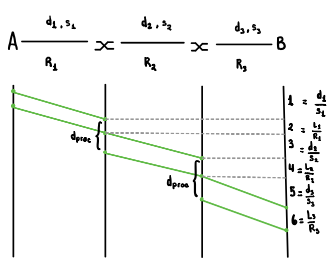
$= 1 - P(x < 20)$

$= 1 -$

$= 1 - 0.99$

Answer : $\boxed{P(x \geq 21) \approx 0.008}$

4.



Answer : End-to-end delay = $\boxed{3\left(\frac{L}{R}\right) + \frac{d_1}{S_1} + \frac{d_2}{S_2} + \frac{d_3}{S_3} + 2(d_{proc})}$

* $L = 1500 \text{ bytes} \cdot \frac{8 \text{ bits}}{1 \text{ byte}} = 12{,}000 \text{ bits}$

* $s = 2.5 \cdot 10^8 \frac{m}{s}$ * $R = 2 \text{ Mbps} \rightarrow 2 \cdot 10^6 \text{ bps}$
* $d_{proc} = 3 \text{ ms} \longrightarrow 0.003 \text{ sec}$
* $d_1 = 5 \cdot 10^6 \text{ m}$
* $d_2 = 4 \cdot 10^6 \text{ m}$
* $d_3 = 1 \cdot 10^6 \text{ m}$

$\Downarrow$

$d_{trans} = \frac{L}{R} = \frac{12000 \text{ bits}}{2 \cdot 10^6 \text{ bps}} = 0.006 \text{ sec}$

* $d_{prog_1} = \frac{d}{S} = \frac{5 \cdot 10^6 \text{ m}}{2.5 \cdot 10^8 \frac{m}{s}} = 0.02 \text{ s}$ * $d_{prog_3} = \frac{1 \cdot 10^6}{2.5 \cdot 10^8} = 0.004 \text{ s}$

* $d_{prog_2} = \frac{4 \cdot 10^6}{2.5 \times 10^8} = 0.016 \text{ s}$

delay = $3(0.006) + 0.02 + 0.004 + 0.016 + 2(0.003)$

Answer : $\boxed{\text{delay} = 0.064 \text{ sec}}$

5. If transmission rate is $R_1 = R_2 = R_3 = R$, then d_{trans}: $\frac{L}{R} = \frac{12{,}000 \text{ bits}}{2 \cdot 10^6 \text{ bps}} = 0.006$ sec

* $d_{proc} = 0$
* $L = 12{,}000$ bits
* $d_{prog_1} = 0.02$ sec
* $d_{prog_2} = 0.016$ sec
* $d_{prog_3} = 0.004$ sec

End-to-End: $\frac{L}{R} + \frac{d_1}{s_1} + \frac{d_2}{s_2} + \frac{d_3}{s_3} = 0.006 + 0.02 + 0.004 + 0.016$

Answer : $\boxed{\text{delay} = 0.46 \text{ sec}}$

6.

* $L = 1500$ byte $\rightarrow$ 12,000 bits
* $R = 2$ Mbps $\longrightarrow$ $2 \cdot 10^6$ bps
* $n = 4$ queue
* $x = \frac{1}{2}$ has been transmitted $= \frac{1500}{2} = 750$ bytes $\rightarrow$ 6000 bits

Queuing Delay $= \frac{n \cdot L}{R} + \frac{L - x}{R} = \frac{nL + (L - x)}{R}$

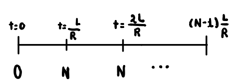
$$\frac{(4)(12{,}000) + [12{,}000 - 6000]}{2 \cdot 10^6}$$

Answer : $\boxed{\text{Queuing delay} = 0.027 \text{ sec}}$

7. a) N pkt

* Each pkt is L
* R = transmission rate

Avg. Queue Delay ?



Traffic Intensity $= \frac{a \cdot L}{R} \Rightarrow \frac{(\frac{R}{\cancel{L}}) \cdot \cancel{L}}{R} = 1$

$$\text{Avg. Queue delay} = \frac{1}{N}\left\{0 + \frac{L}{R} + 2\frac{L}{R} + \dots (N-1)\frac{L}{R}\right\} \Rightarrow \frac{L}{\cancel{N}R}\underbrace{(N-1)}_{\frac{(N-1)\cdot \cancel{N}}{2}}$$

Answer : $\boxed{\text{Avg. Queue} = \frac{L}{2R}(N-1)}$

b) * Since it takes $\frac{LN}{R}$ for packet to arrive, mean that the queue is empty each time a new batch arrive. Hence the avg. queue delay is the same as the answer in part A.

Answer : $\boxed{\frac{L}{2R}(N-1)}$

8. a) * $I = \frac{a \cdot L}{R}$

* Queuing delay take the form $\frac{I \cdot L}{R(1-I)}$ for $I < 1$

* Formula of queue delay + transmission delay ?

Total delay : Queue + Transmit

$$\frac{I \cdot L}{R(1-I)} + \frac{L}{R}$$

$$\frac{L}{R}\left(\frac{I}{(1-I)} + 1\right) \cdot (1-I)$$

$$\frac{L}{R}\left(\frac{\cancel{I} + (1-\cancel{I})}{(1-I)}\right)$$

Answer : $\boxed{\frac{L}{R}\left(\frac{1}{1-I}\right)}$

b) * assume $a = 10$

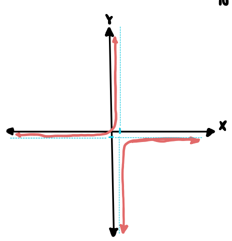
* $\frac{L}{R}\left(\frac{1}{1-I}\right) \rightarrow x\left(\frac{1}{1-I}\right) \rightarrow \frac{x}{1-10x}$

* Assign $x = \frac{L}{R}$ $\quad I = \frac{aL}{R} = a \cdot x$, $a = 10$

$x = 0.1 \rightarrow \frac{1}{10}$

$y = -0.1 \rightarrow \frac{1}{10}$

Answer : Graph of Function



9. * $\mu = R$ $\quad$ * Equation from #8. : $\frac{I \cdot L}{R(1-I)}$ where $I = \frac{a \cdot L}{R} \rightarrow \frac{a \cdot L}{\mu}$

* $a = \frac{pkt}{sec}$

replace

$$\frac{I \cdot L}{\mu(1-I)}$$

* In term of "μ" & "a" - Total delay $= d_{queue} + d_{trans}$

$$= \frac{IL}{\mu(1-I)} + \frac{L}{\mu}$$

$$= \frac{L}{\mu}\left(\frac{I}{(1-I)} + 1\right) \cdot (1-I)$$

$$= \frac{L}{\mu}\left(\frac{\cancel{I} + (1-\cancel{I})}{(1-I)}\right)$$

$$= \frac{L}{\mu}\left(\frac{1}{1-I}\right) \rightarrow \frac{L}{\mu}\left(\frac{1}{1-\frac{aL}{\mu}}\right) \cdot \mu = \frac{L}{\cancel{\mu}}\left(\frac{1}{\frac{\mu - aL}{\cancel{\mu}}}\right)$$

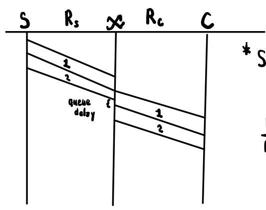
Answer: $\boxed{\frac{L}{\mu - a \cdot L}}$

10. a) * Same d_{prop}
* Rate = R_s

$\}$ The inter-arrival time $\rightarrow d_{trans} = \frac{L}{R_s}$

Answer: $\boxed{\text{Transmit} = \frac{L}{R_s}}$

b)



* Since $R_s > R_c \rightarrow R_s$ is bigger / faster

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

$$\frac{L}{R_s} + T \geq \frac{L}{R_c} \Rightarrow \text{Answer: } \boxed{T = \frac{L}{R_c} - \frac{L}{R_s}}$$

11. * $d = 20{,}000$ km $\rightarrow 2 \cdot 10^7$ m
* $R = 2$ Mbps $\rightarrow 2 \cdot 10^6$ bps
* $s = 2.5 \cdot 10^8 \frac{m}{s}$

a) Bandwidth delay $= R \cdot \overbrace{d_{prop}}^{\frac{d}{s}} = (2 \cdot 10^6 \text{bps}) \cdot \left(\frac{2 \cdot 10^7 m}{2.5 \cdot 10^8 \frac{m}{s}}\right) = \boxed{160{,}000 \text{ bits}}$ Answer

b) From the answer above, 160,000 bits is the most that Host A can transfer to Host B. So, 800,000 bits is too much to send continously.

Answer: $\boxed{160{,}000 \text{ bits}}$

c) In term of bandwidth delay, the delay is equal to the maximum amount of file can be send through the link

Answer: $\boxed{\text{Bandwidth delay} = \text{Max file size}}$

d) Length of 1 bit $= \frac{s}{R} \Rightarrow L = \frac{2.5 \cdot 10^8 \frac{m}{s}}{2 \cdot 10^6 \text{ bps}} = 125 \frac{m}{bit}$

*A football field $\approx$ 91.44 m

Answer: $\boxed{125 \frac{m}{bit}\text{, and YES longer than football field}}$

e) width $= \frac{\text{speed} \cdot \text{rate}}{\text{link Length (m)}} \Rightarrow$ Answer: $\boxed{\text{width} = \frac{s \cdot R}{m}}$

12. * $R = 10$ Mbps $\rightarrow 1.0 \cdot 10^7$ bps * $d = 36{,}000$ km $\rightarrow 3.6 \cdot 10^7$ m
* $s = 2.4 \cdot 10^8 \frac{m}{s}$

a) $d_{prop} = \frac{d}{s} = \frac{3.6 \cdot 10^7 m}{2.4 \cdot 10^8 \frac{m}{s}} = 0.15$ sec Answer: $\boxed{0.15 \text{ sec}}$

b) $d_{bandwidth} = R \cdot d_{prop} = 1.0 \times 10^7 \text{ bps} \cdot 0.15 = 1{,}500{,}000$ bits Answer: $\boxed{1{,}500{,}000 \text{ bits}}$

c) * Every minute a photo is take 1 min = 60 sec. $d_{bandwidth} \rightarrow 1.0 \times 10^7 \text{ bps} \cdot 60 \text{ sec} = 600{,}000{,}000$ bits

for the minimum

Answer: $\boxed{600{,}000{,}000 \text{ bits}}$

13. * End-to-end transport

* $L = 8 \cdot 10^6$ bits
* $R_i = 2$ Mbps $\rightarrow 2 \cdot 10^6$ bps

a) Time to move packet $d_{trans} = \frac{L}{R} \rightarrow \frac{8 \cdot 10^6}{2 \cdot 10^6} = \boxed{4 \text{ sec}}$ Answer[1], but it has to pass 3 link so it is 12 sec

Answer[2]: $\boxed{12 \text{ sec}}$

b) * 800 pkt

1 pkt = 10,000 bits

① For the 1^{st} pkt to 1^{st} switch $\rightarrow d_{trans} = \frac{L}{R} = \frac{1 \cdot 10^4}{2 \cdot 10^6} = \boxed{0.005 \text{ sec}}$ Answer[1]

② 2nd pkt at first switch = 1^{st} pkt at 2nd switch = 0.005 sec $\cdot 2 = \boxed{0.01 \text{ s}}$ Answer[2]

c) With 1^{st} pkt is total of 0.005 sec $\cdot$ 3 links = 0.015 s to get to the end, with 800 pkts we can do $\underbrace{0.015 \text{ sec}}_{\text{1st pkt to arrive}} + \underbrace{799 \cdot 0.005 \text{s}}_{\text{remain}} = \boxed{4.01 \text{ sec}}$ Answer[1]

With this compare to Ⓐ $\frac{4.01 \text{s}}{\underbrace{12 \text{s}}_{\text{Part a}}} \approx \boxed{\frac{1}{3}}$ delay using segmentation Answer[2]

d) Answer: Without segmentation, the bit error will not be tolerate and file will be retransmit again from the beginning, and this is a hassle.

e) Answer: The drawback of segmentation is that it may have many smaller pkts, which the header size is usually the same size for all pkts. So having segmentation can result in lots of header.

15. a) Answer[1]: $\boxed{\text{Google IP} = 216.58.193.78}$

Answer[2]: Change the number from 10 to 5 mean how much pkt to send to the address.

b) Answer[1]: I see a total of $\boxed{10}$ hops was made.

Answer[2]:

Hop #	Source IP	Destination IP	RTT
1	192.168.1.1	96.120.60.101	1 ms
2	96.120.60.101	162.151.125.213	20 ms
3	162.151.125.213	68.87.216.253	13 ms
4	68.87.216.253	68.86.92.217	129 ms
5	68.86.92.217	68.86.86.226	14 ms
6	68.86.86.226	50.242.149.198	16 ms
7	50.242.149.198	108.170.233.47	24 ms
8	108.170.233.47	209.85.242.37	22 ms
9	209.85.242.37	216.58.193.78	47 ms
10	216.58.193.78	Done	41 ms

c) Answer[1]: Machine IP = 192.168.1.1

Answer[2]: The hop that my machine is hop 1

Answer[3]: The second router IP is 96.120.60.101