Computer Networks - Homework 1

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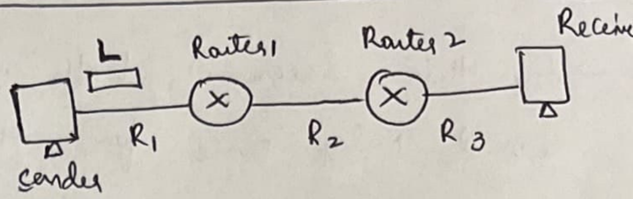
1). As per question,



Link Speed of R1, R2, R3 ⇒ 1Mbps.

Length of each link ⇒ 100km

Packet size of transmitter ⇒ 1KB

Propagation Speed of Packet ⇒ 20,000 km/s.

Processing time of packet at each router ⇒ 5 μs.

a). Both Routers are "store-and-forward" routers

→ for store-and forward routers in this scenario; delay includes transmission of the packets through 3 links, propogation through 3 links and processing through 2 routers.

End-to-End delay for the scenario ⇒ $3(\text{delay}_{\text{transmission}}) + 3(\text{delay}_{\text{propaga-}})$ $+ 2(\text{delay}_{\text{processing}})$.

• Transmission Delay ⇒ $\dfrac{\text{Length of Packet}}{\text{Link speed}} \Rightarrow \dfrac{1KB}{1\,Mbps} \Rightarrow \dfrac{1 \times 8\ kbps}{1 \times 10^3\ kbps}$

$\Rightarrow 0.008\,s \approx 8\,ms$ #

• Propagation Delay ⇒ $\dfrac{\text{Length of each link}}{\text{Propagation Speed}} \Rightarrow \dfrac{100\ km}{20{,}000\ km/s} \Rightarrow \dfrac{1}{200}\ sec$

$\Rightarrow 5\,ms$ #

• Processing time ⇒ $5\mu s. \Rightarrow 5 \times 10^{-3}\ ms$ #

T. delay ⇒ $3(8ms) + 3(5ms) + 2(5 \times 10^{-2} ms)$

⇒ $(24 + 15 + 0.01)\ ms \Rightarrow 39.01\ ms$ #

b). Both routers are 'cut-through'.

⇒ As cut-through routers doesnot wait for entire packet to arrive, So, we count only once for the delay in transmission.

→ for this scenario, both the routers are cut-through and count only once for the delay in transmission.

Total End-to-End delay $\Rightarrow (\text{delay}_{\text{Trans}}) + 3(\text{delay}_{\text{prop.}}) + 2(\text{delay}_{\text{proc.}})$.

$$\Rightarrow 8\,ms + 3 \times (5\,ms) + 2(5 \times 10^{-3}\,ms)$$

$$\Rightarrow (8 + 15 + 0.1)\,ms$$

$$\Rightarrow 23.01\,ms \#$$

c). Link Speed of R1, R2, R_3 ⇒ 1 Gbps.

- New Transmission Delay $\Rightarrow \dfrac{\text{Length of Packet}}{\text{Link Speed}} \Rightarrow \dfrac{1\,KB.\ 8\,\text{bits/byte}}{10^6\ Kbps.}$

$$\Rightarrow 8\,\mu s \#$$

- Propagation Delay ⇒ 5 ms {doesn't change}
- Processing Delay ⇒ 5 μs {doesn't change}

i) Store & forward :

End-to-End Delay $\Rightarrow 3(\text{delay}_{\text{trans}}) + 3(\text{delay}_{\text{prop.}}) + 2(\text{delay}_{\text{procen}})$

$$\Rightarrow 3(8 \times 10^{-3}\,ms) + 3(5\,ms) + 2(5 \times 10^{-3}\,ms)$$

$$\Rightarrow 0.024\,ms + 15\,ms + 0.01\,ms$$

$$\Rightarrow 15.034\,ms \#$$

ii) Cut-through :-

End-to-End Delay $\Rightarrow (\text{delay}_{\text{trans}}) + 3(\text{delay}_{\text{prop}}) + 2(\text{delay}_{\text{procen}})$

$$\Rightarrow 8 \times 10^{-3}\,ms + 3(5\,ms) + 2(5 \times 10^{-3}\,ms)$$

$$\Rightarrow (0.008 + 15 + 0.01)\,ms \Rightarrow 15.018\,ms \#$$

d). Link Speed of $R_1, R_2 \Rightarrow$ 2Mbps
Link Speed of $R_3 \Rightarrow$ 1 Mbps.

3 Packet Size of Same Length $\Rightarrow$ 1KB.

- Transmission delay of R_1 and R_2 Links.

$$(d_{trans})_{R_{1,2}} \Rightarrow \frac{1\text{ KB} \cdot 8 \text{ bits/Bytes}}{2 \cdot \times 10^3 \text{ kbps}} \Rightarrow 0.4 \times 10^{-2} \Rightarrow 4\text{ms} \#$$

$$(d_{trans})_{R_3} \Rightarrow \frac{1\text{ KB} \cdot 8 \text{ bits/Byte}}{1 \times 10^3 \text{ kbps}} \Rightarrow 8\text{ms} \#$$

- Propagation delay $\Rightarrow$ 5ms #
- Processing delay $\Rightarrow$ 5 μs #.

i) Store & forward :

End-to-End delay $\Rightarrow 2(\text{delay}_{trans})_{R_1R_2} + 3(\text{delay}_{prop}) + 2(\text{delay}_{proces})$ neglected.

{for packet 1} $+ 1(\text{delay}_{trans})_{R_3}$

$$\Rightarrow \{2(4\text{ms}) + 8\text{ms}\} + 3(5\text{ms})$$

$$\Rightarrow (16 + 15)\text{ms} \Rightarrow 31\text{ms} \#$$

For packet 2 :-

→ due to the change in Link Speeds between $(R1, R_2)$ and R_3 i.e $(8-4)$ms $\Rightarrow$ 4ms, the second packet has to wait for another 4ms.

End-End-delay $\Rightarrow$ Service time + 1^{st} packet delay $\Rightarrow (4+31)$ms $\Rightarrow$ 35ms #

for 3rd Packet :-

End-to-End delay ⇒ (Service time) + 2nd packet delay Time

⇒ (4 + 35) ms

⇒ 39 ms #.

Cut-through :-

End-to-End delay ⇒ $(delay_{prop.}) + (delay_{trans}) + (delay_{proces})$

- delay for packet 1 ⇒ $3(d_{prop.}) + d_{trans}$ {at the last link}.

⇒ 3 (5) + 8

⇒ 23 ms #

- delay for Packet 2 ⇒ Time taken for Packet 1 {till now} + process time

⇒ 23 ms + 4 ms

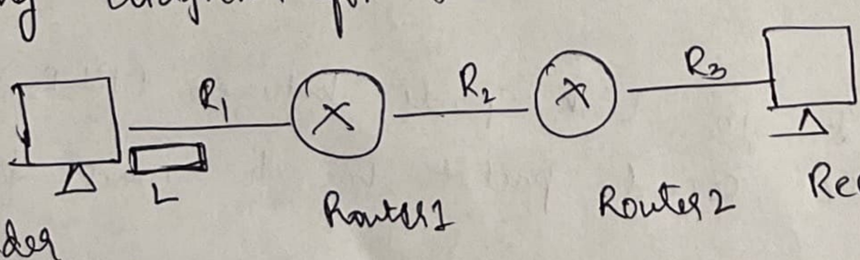
⇒ 27 ms #

- delay for packet 3 ⇒ Time elapsed till now + pack 2 procrsing timed

⇒ 27 ms + 4 ms

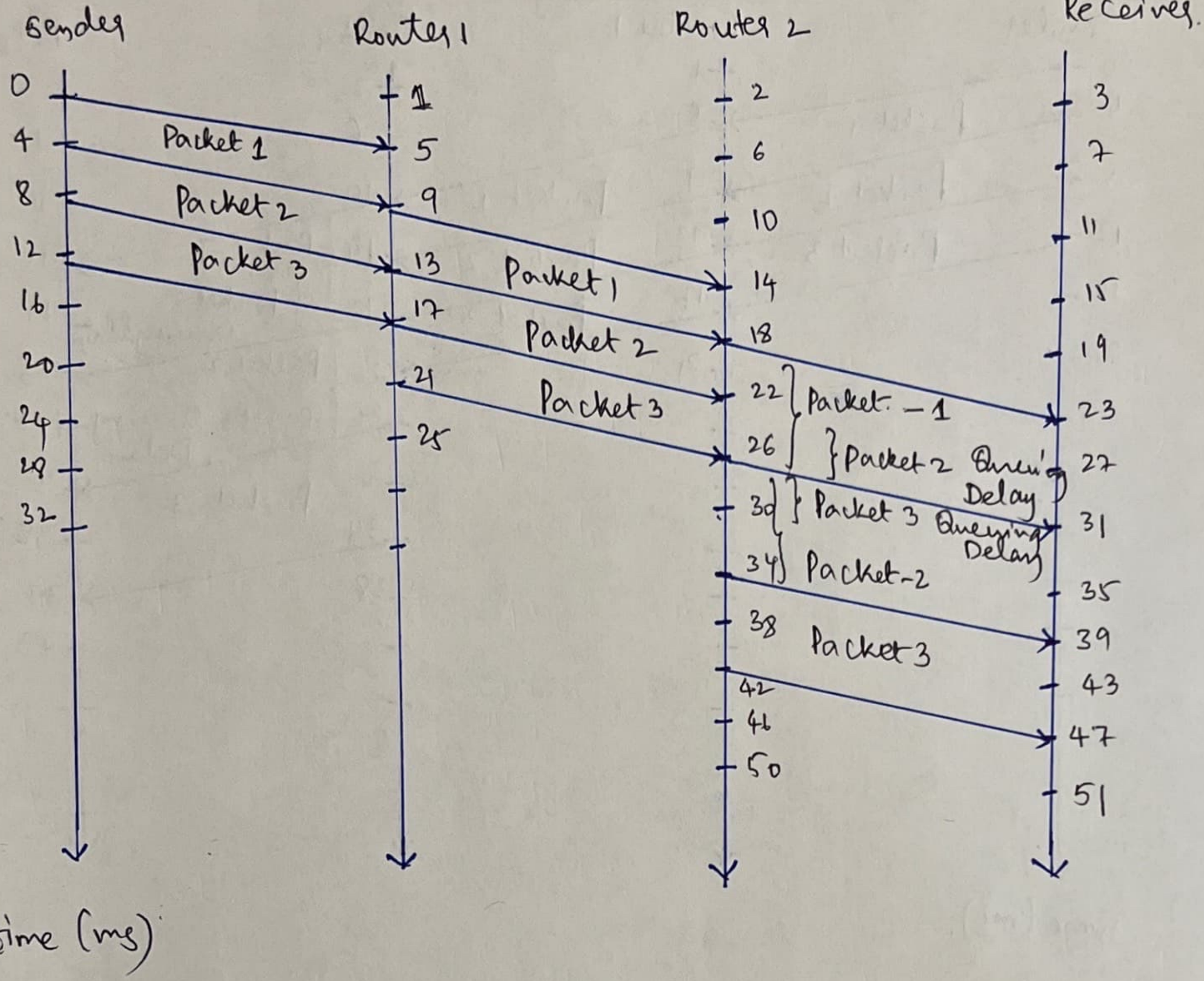
⇒ 31ms #

e). Timing diagram for the Scenario.

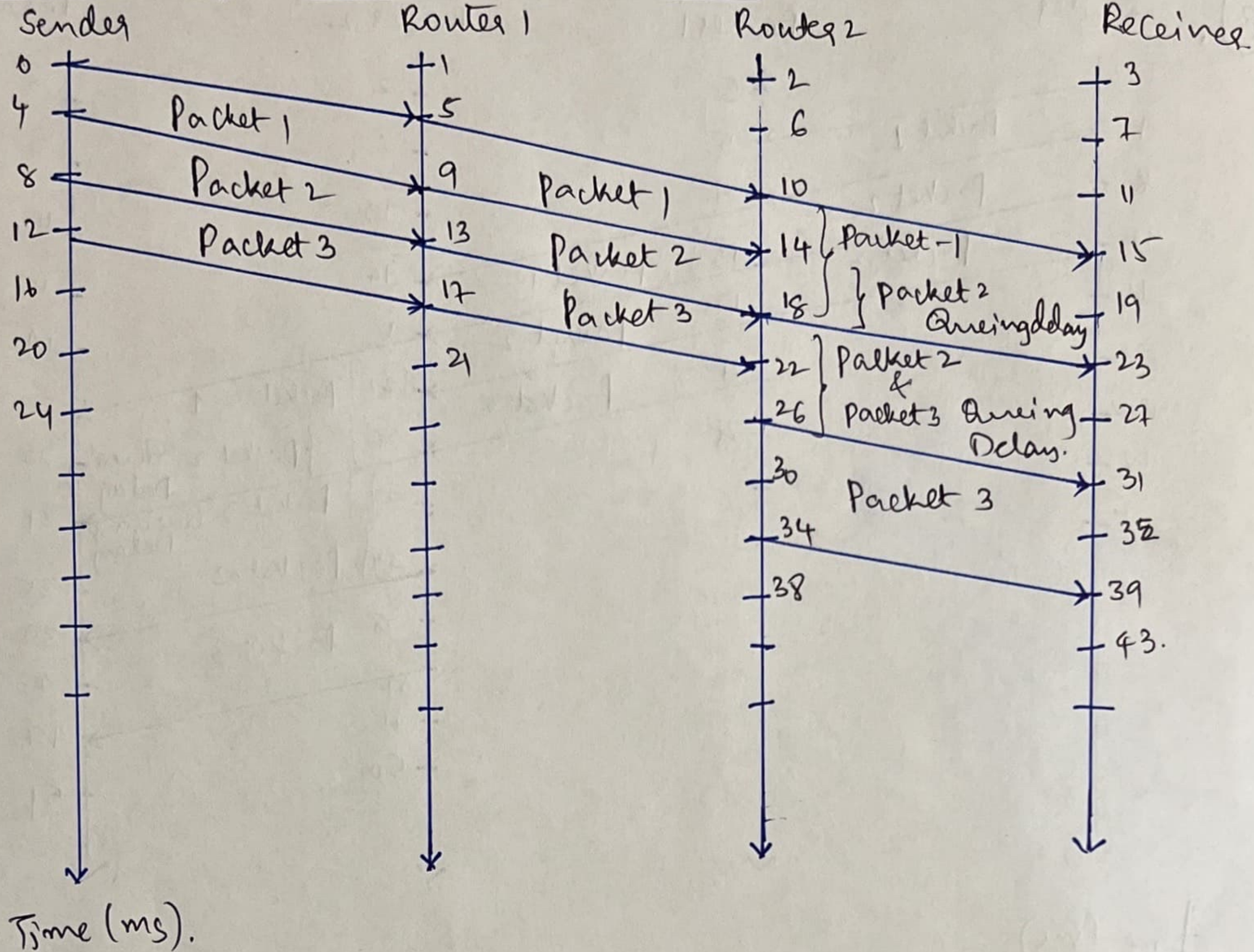


Timing Diagram for Store & forward routers:-

(e).

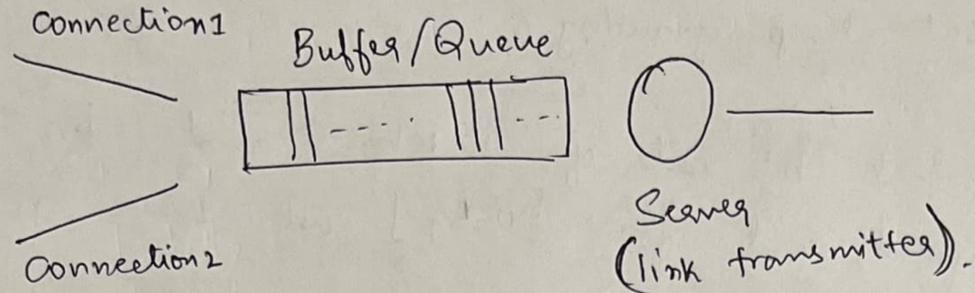


Timing Diagram for cut through routers:-

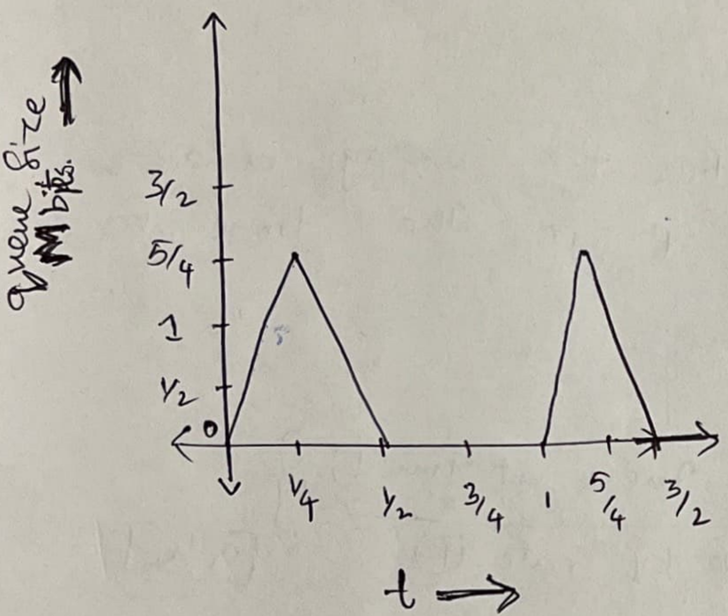


2.

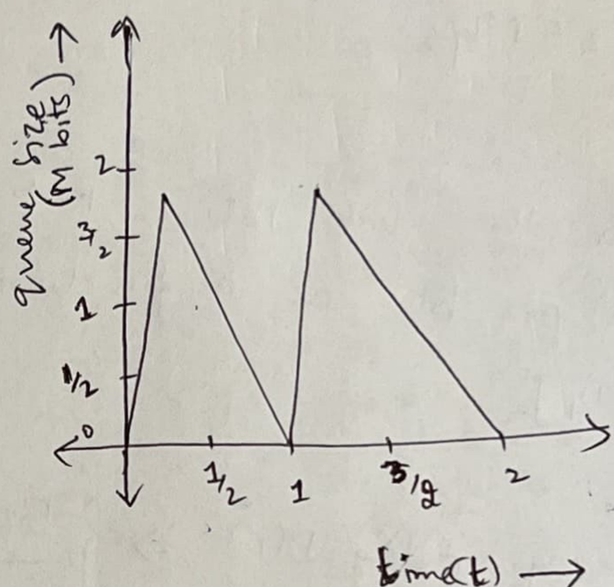
a)



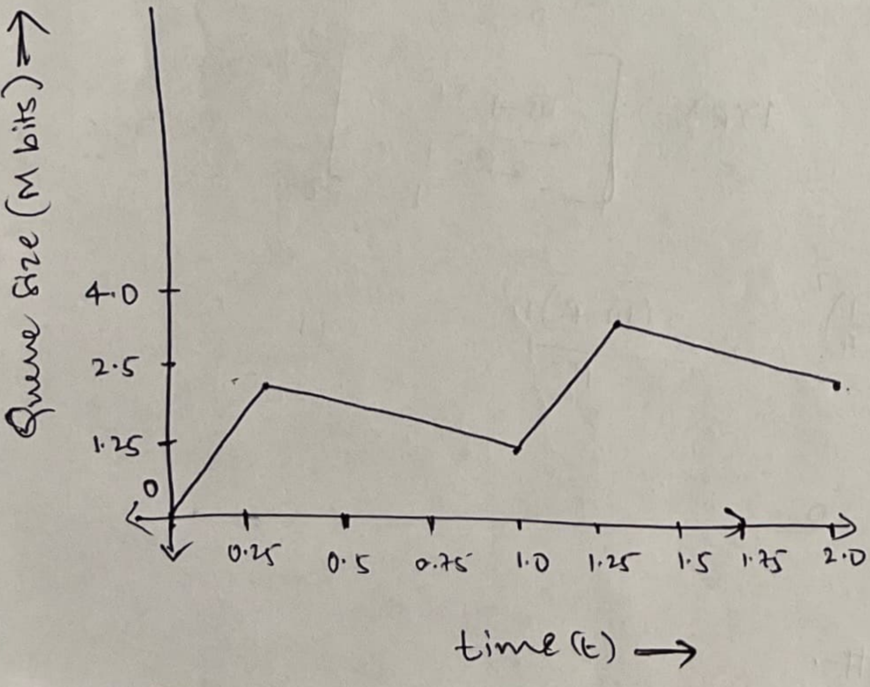
a) R > 2.5 Mbps.



R = 2.5



R < 2.5 Mbps



b) What is the minimum value R_0 of R so that this occupancy doesn't keep growing?

→ for the given link bit rate of 10 Mbps and the time interval ; t = 1 second, and for [0, 1/4] we have received

$10 \times \frac{1}{4}$ Mbps ⇒ 2.5 Mbps.

→ The min. value of R so that occupancy doesn't keep growing is 2.5 Mbps.

C). for the link rate $10 \geq R \geq R_0$, the average delay D(R) per bit as a function of R. in the time range [0, 1/4].

$$\text{Average delay } D(R) \Rightarrow \left\{ \frac{\text{Size of Queue at Time}(t)}{\text{Link bit rate }(R)} \right\}_{[0,\,1/4]}.$$

- Queue size ⇒ $q(t) = (10-R)t$
- $t \in [0, 1/4]$

$$D(R) = \frac{1}{4} \int_0^{1/4} \frac{(10-R)\cdot t}{R} \cdot dt$$

$$D(R) \Rightarrow \left[\frac{(10-R)t^2}{2R \cdot \frac{1}{4}} \right]_0^{1/4}$$

$$D(R) = \frac{2(10-R)\left(\frac{1}{4}\right)^2}{R} - \frac{2(10-R)0}{R}$$

$$D(R) \Rightarrow \frac{10-R}{8R} - 0$$

$$\boxed{D(R) = \frac{10-R}{8R}}$$ #.

d). for $10 \geq R \geq R_0$; Express the average buffer occupancy (5)
(overtime) $L(R)$ as a function of R.

→ Average buffer time is defined as below.

$$L(R) = \int_0^{t_0} q(t) \cdot dt \qquad \{ \because q(t) \Rightarrow \text{Size of Queue.}$$

$[0, 1/4]$ with 10 Mbps.

$$q(t) = (10-R)t.$$

$$[1/4, t_0] \Rightarrow q(t) = 2.5 - Rt$$

$$L(R) = \int_0^{t_0} q(t) \cdot dt \Rightarrow \int_0^{1/4} (10-R)t \cdot dt + \int_{1/4}^{t_0} (2.5 - Rt) \cdot dt$$

$$\Rightarrow \left[(10-R) \cdot \frac{t^2}{2} \right]_0^{1/4} + \left[2.5t \right]_{1/4}^{t_0} - \left[R \cdot \frac{t^2}{2} \right]_{1/4}^{t_0}$$

$$\Rightarrow \frac{(10-R) \cdot \frac{1}{16}}{2} - 0 + \left[2.5 t_0 - \frac{2.5}{4} \right] - \left[\frac{R t_0^2}{2} - \frac{R \cdot \frac{1}{16}}{2} \right].$$

→ time to empty buffer $\Rightarrow \frac{1}{4} \cdot \frac{10}{R} \Rightarrow \frac{2.5}{R}$ #

$$L(R) \Rightarrow \frac{10-R}{32} + \left[2.5 \cdot \left(\frac{2.5}{R} \right) - \frac{2.5}{4} \right] - \left[\frac{R \cdot \left(\frac{2.5}{R} \right)^2}{2} - \frac{R}{32} \right]$$

$$\Rightarrow \frac{10-R}{32} + \frac{6.25}{R} - \frac{2.5}{4} + \frac{R}{32} - \frac{6.25}{2R}$$

$$\Rightarrow \left(\frac{5}{16} - \frac{2.5}{4} \right) + 2.5 \left(\frac{2.5}{R} - \frac{1}{4} \right)$$

$$L(R) \Rightarrow \frac{2.5}{R} \left(\frac{10-R}{8} \right) \Rightarrow 2.5 \left\{ \frac{10-R/8}{R} \right\} \approx 2.5 * \text{Average Delay}$$

$$\boxed{L(R) = 2.5\, D(R)}$$ #

e). Show $L(R) = \lambda . D(R)$

where $\lambda = 2.5$ Mbps is the average arrival rate of bits.

→ from 'd', we have $L(R) = 2.5 D(R)$ and on comparing it with $L(R) = \lambda . D(R)$

we have $\lambda = 2.5$ Mbps #.

3. Chapter 1 – P3 :-

Consider an application that transmits data at a steady rate. Also, when such an application starts, it will continue for a long period of time.

a). Would a packet-switched or a circuit switch network be more appropriate for this application? why?

A→ As per the given requiments in the question that the transmission of data to be steady and it should have a smooth bandwidth meeting the requirements with longer meeting times.

→ Thus, "Circuit switched Network" would be an appropriate choice for the application as the rate is smooth and not bursty. Also, we can minimize bandwidth wastage, and able to store all application sessions.

→ Also, setting up costs and tearing down costs are negligible for big/extended application sessions.

b). Suppose if packet-switched network is used, and only traffic comes from such an app, Is some form of congestion control needed? why? (6)

Ans: ⇒ with the use of "Packet-Switching" network, we have an advantage of having no congestion mechanism that would be required for the scenario.

⇒ It is because, we already have sufficient bandwidth to handle all the data rates of the application.

⇒ for the worst case scenario, all applications transmit data over one/more data links, which eliminate the need for a mechanism for congestion control.

4). Chapter 1 : P8 :

Suppose users share a 3Mbps link. Also suppose each user requires 150 kbps when transmitting, but each transmits only 10%

a). when circuit switching is used, how many users can be supported?

Ans:

# of supported users in circuit switching ⇒ $\left\{ \dfrac{\text{Capacity Link}}{\text{Capacity utilized by each link for transmitting}} \right\}$

- Capacity of link = R ⇒ 3Mbps.
- Capacity utilized to transmit ⇒ r ⇒ 150 kbps.

# of user ⇒ $\frac{R}{r} = \frac{3\text{ Mbps}}{150\text{ kbps}} \Rightarrow \frac{\cancel{3} \times 10^{\cancel{6}\,2}}{{}_{5}\cancel{15} \times 10^{\cancel{4}}} \Rightarrow \frac{100}{5} = 20$ users

b) Suppose packet switching is used, find the probability that a given user is transmitting.

→ given only 10% of time user is transmitting. so, the probabil -ty of user to transmit will be 0.1.

c). Suppose there are 120 users, find the probability that exactly 'n' users are transmitting at any given time.

Ans → As per question, we have 120 users and at any given time, n users transmit, and probability being 0.1

→ By Binomial Distribution of n users transmitting in 120 is given as ⇒ $^{120}C_n * P^n \times (1-P)^{120-n}$

$$P' \Rightarrow {}^{120}C_n \, (0.1)^n * (0.9)^{120-n} \quad \#$$

d). find probability that there are 21 or more users transmitting simultaneously.

→ Probability $P'' \Rightarrow \sum_{i=21}^{120} {}^{120}C_i \, P^i * (1-P)^{120-i}$

$$P'' \Rightarrow 1 - \sum_{i=0}^{20} {}^{120}C_i \, (1-P)^{120-i}$$

$\{ P + (1-P) = 1$

$P_1 + P_2 = 1 \}$

5. Chapter 1 : P14:-

Consider the queuing delay in router buffer, Let 'I' denote the traffic intensity $I = \frac{La}{R}$, Suppose queuing delay takes form

$\frac{IL}{R(1-I)}$ for all $I<1$

a) provide a formula for total delay that is queuing delay + transmission delay.

$\rightarrow$ • Queuing Delay $\Rightarrow \frac{IL}{R(1-I)}$ for $I<1$

• Transmission Delay $\Rightarrow \frac{L}{R}$

Total delay $\Rightarrow$ Queuing Delay + Transmission Delay.

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

Total Delay $\Rightarrow \frac{L}{R}\left(\frac{I}{1-I}+1\right) \Rightarrow \frac{L}{R}\left(\frac{I}{1-I}\right)$ #

b). Plot the total delay as a function of L/R

Ans

• Total delay $\Rightarrow \frac{L}{R(1-I)} \rightarrow ①$

• Traffic Intensity $\Rightarrow I = \frac{La}{R} \rightarrow ②$

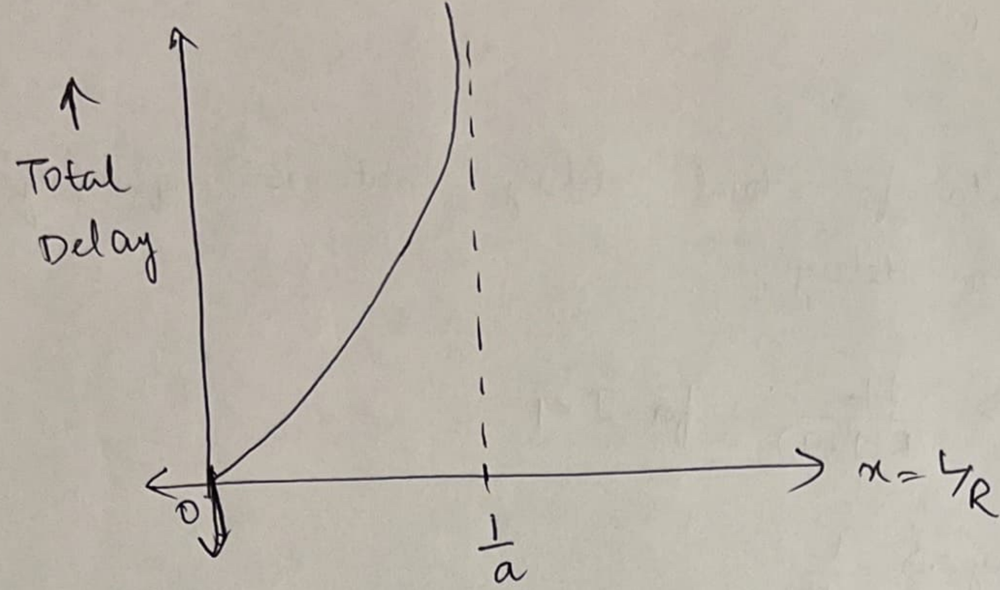
Total delay obtained by Inserting I in ①

$$\text{Total delay} = \frac{L}{R\left(1-\frac{La}{R}\right)} \Rightarrow \frac{L/R}{1-\left(\frac{L}{R}\right).a}$$

* Consider a new variable $x = L/R$

Total delay $\Rightarrow \frac{x}{1-ax}$ #

$1-ax=0$; $x = 1/a$. when $x=0$; it becomes zero.



Problem 6:- chapter 1, P16 :-

Suppose an average buffer contains 10 packets, average packet queuing delay is 10ms. The transmission rate is 100 packets/sec. Using little's formula, what is the average packet arrival rate, assuming there is no packet loss.

Ans:- Little formula $\Rightarrow N = a \cdot d$

- $N \Rightarrow$ Average Packet in buffer + packets being transmitted

$N \Rightarrow 10 + 1 = 11$

- $d \Rightarrow$ total delay.

$N \Rightarrow a \cdot$ (queuing delay + transmission delay)

$11 \Rightarrow a \cdot \left(10\,ms + \frac{1}{100}\,s\right)$

$11 = a \cdot \left(10 \times 10^{-3} + 10^{-2}\right) s$

$a = \frac{11}{2 \times 10^{-2}}\ s$

$a = \frac{1100}{2} \Rightarrow 550$ packets/sec #

Issue Observed

→ Here, we have 550 packets/sec and the average packet rate is greater than the transmission rate given 100 p/s

→ It makes the Queue unstable by making traffic Intensity to cross large bounds greater than 1

→ And also, little's formula is applicable for only stable & Steady networks.

(7) Chapter 1 : P18

a) find average & Standard deviation of the round-trip delays at each of three hours.

Ans:- At each of three hours, Average {14.76 ms, 12.41 ms, 8.3727} and the standard deviation tends to be {7.85 m, 6.048 ms, 5.022 ms}.

b). find the number of routers at each of 3hrs. Did the path change during any of the hours.

→ Traceroute has '10' routers at each of 3hrs, and the path has not changed during any of the hours.

c). Try to identify number of ISP networks. will largest delays occur?

→ while the traceroute, it passed through '4' ISP Networks and the largest delays do occur at the peering interface in between adjacent Internet service providers.

d). Repeat above for Source & destination on different Continents. Compare the intra-Continent and inter-Continent results.

Avg ⇒ {29.55ms, 62.21 ms, 27.08ms} SD ⇒ {18.55ms, 96.26ms, 15.07 ms}

⇒ with the inter continent scenario, the average round trip delay with traceroute are Standard deviation are as above.

- There are a total of '8' routers between the source and destination, and the paths have not changed from Source and destination in three hours.

- there are a total of '4' Internet Service Providers and largest delays occured at peering interfaces between adjacent ISP's.

8. Ch1 : P25 :-

a) Calculate the bandwidth delay product $R \cdot d_{prop}$.

Ans:- as the distance between two hosts A & B (d_{AB} = 2000km)

- Speed of propagation in link ⇒ 2×10^8 m/s.

- Bandwidth Delay product ⇒ $R \cdot d_{prop}$

$$\Rightarrow R \cdot \left\{ \frac{d_{AB}}{\text{prop. Speed}} \right\}$$

$$\Rightarrow 2 \text{ Mbps} * \frac{2000 \text{ km}}{2.5 \times 10^8 \text{ m/s}}$$

$$\Rightarrow 2 \times 10^6 \text{ bits/s} * \frac{2000 \times 10^3 \text{ m}}{25 * 10^7 \text{ m/s}}$$

$$\Rightarrow \frac{4 * 10 * 10 * 10^4}{25} \text{ bits}$$

Bandwidth Delay Product ⇒ 16000 bits #

b). Consider Sending file of 800000 bits from host A → B. Suppose file is sent continously as a large message, what is maximum number of bits that will be in the link at any time.

→ Maximum # of bits at any time is

⇒ min (800,000 bits, bandwidth delay product)

⇒ min (800,000 bits, 160000 bits)

⇒ 160000 bits #

c). Provide ~~an~~ integpratation of bandwidth - delay product.

→ Bandwidth - delay product can be interpretted as the max # of bits that can be transmitted in a link

e) Derive a general expression for the width of a bit in terms of propagation Speed s, transmission rate R and length of link m.

Ans:- The width of a bit can be expressed as ⇒ $\frac{\text{length of link}}{\text{bandwidth - delay prod}}$

$$\text{width} \Rightarrow \left\{ \frac{m}{R \cdot d_{prop}} \right\}$$

$$\Rightarrow \left\{ \frac{m}{R \cdot \frac{d}{speed}} \right\} \Rightarrow \frac{m}{R \cdot \frac{m}{s}}$$

$$\boxed{\text{width of bit} = \frac{S}{R}}$$ #

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Question - 7d

try ①	try ②	try ③
1. 4.038 ms	1. 5.636 ms	1. 10.932 ms
2. 10.538 ms	2. 16.186 ms	2. 12.256 ms
3. 8.723 ms	3. 28.404 ms	3. 21.337 ms
4. 51.295 ms	4. 14.821 ms.	4. 10.687 ms
5. 39.758 ms	5. 39.230 ms	5. 38.071 ms
6. 43.160 ms	6. 57.731 ms	6. 36.224 ms
7. 41.291 ms	7. 296.873 ms	7. 49.028 ms
8. 37.593 ms	8. 38.835 ms	8. 38.152 ms
Total ⇒ 236.402 ms.	Total ⇒ 497.716	Total ⇒ 216.687
Mean ⇒ 29.55 ms.	Mean ⇒ 62.21	Mean ⇒ 27.08
S.D ⇒ 18.55 ms	S.D ⇒ 96.26	S.D ⇒ 15.075

8 – Total routers

4 - ISP

uf.edu

Question – 7 a, b, c

try ①	try ②	try ③
1. 4.789 ms	1. 6.248 ms	1. 5.646 ms
2. 18.499 ms	2. 10.779 ms	2. 12.423 ms
3. 26.551 ms	3. 13.709 ms	3. 13.562 ms
4. 16.085 ms	4. 11.982 ms	4. 11.142 ms
5. 13.246 ms	5. 13.203 ms	5. 16.631 ms
6. 13.027 ms	6. 12.242 ms	6. 12.899 ms
7. 0.	7. 0	7. 0
8. 23.419 ms	8. 16.004 ms	8. 14.938 ms
9. 15.769 ms.	9. 18.690 ms	9. 15.086 ms
10. 16.224 ms.	10. 21.339 ms	10. 13.031 ms.
Total ⇒ ~~142~~ 147.609.	Total ⇒ 124.196	Total ⇒ 83.727
Mean ⇒ 14.76	Mean ⇒ 12.4196	Mean ⇒ 8.3727
S.D ⇒ 7.85	S.D ⇒ 6.048	S.D ⇒ 5.022

10 – Total routers.

4 – ISP

Question 7(a,b,c) – Intra – Continent Trace Route

Hour 1: traceroute ufl.edu

```
[(base) jaswanth@jaswanths-MacBook-Air ~ % traceroute ufl.edu
traceroute to ufl.edu (128.227.36.35), 64 hops max, 52 byte packets
 1  192.168.0.1 (192.168.0.1)  19.635 ms  3.669 ms  6.248 ms
 2  10.4.0.1 (10.4.0.1)  41.362 ms  12.803 ms  10.779 ms
 3  100.122.94.76 (100.122.94.76)  29.836 ms  12.717 ms  13.709 ms
 4  ip72-214-194-3.ga.at.cox.net (72.214.194.3)  23.583 ms  20.180 ms  11.982 ms
 5  wsip-184-188-101-187.at.at.cox.net (184.188.101.187)  20.140 ms  24.496 ms  13.203 ms
 6  ssrb230a-pel-asr9001-1-v16-1.ns.ufl.edu (128.227.236.204)  25.983 ms  14.884 ms  12.242 ms
 7  * * *
 8  ssrb230a-nexus-msfc-1-v15-1.ns.ufl.edu (128.227.236.202)  21.520 ms  18.111 ms  16.004 ms
 9  ssrb230a-dcpopl3-7009-1-vdc2-v601-1.ns.ufl.edu (128.227.236.155)  21.286 ms  12.412 ms  18.690 ms
10  presidentialsearch.ufl.edu (128.227.36.35)  25.939 ms  15.566 ms  21.339 ms
(base) jaswanth@jaswanths-MacBook-Air ~ %
```

Hour 2: traceroute ufl.edu

```
[(base) jaswanth@jaswanths-MacBook-Air ~ % traceroute ufl.edu
traceroute to ufl.edu (128.227.36.35), 64 hops max, 52 byte packets
 1  192.168.0.1 (192.168.0.1)  21.661 ms  10.218 ms  4.789 ms
 2  10.4.0.1 (10.4.0.1)  24.750 ms  26.006 ms  18.499 ms
 3  100.122.94.76 (100.122.94.76)  28.383 ms  18.607 ms  26.551 ms
 4  ip72-214-194-3.ga.at.cox.net (72.214.194.3)  34.057 ms  14.912 ms  16.085 ms
 5  wsip-184-188-101-187.at.at.cox.net (184.188.101.187)  23.357 ms  14.841 ms  13.246 ms
 6  ssrb230a-pel-asr9001-1-v16-1.ns.ufl.edu (128.227.236.204)  31.224 ms  15.337 ms  13.027 ms
 7  * * *
 8  ssrb230a-nexus-msfc-1-v15-1.ns.ufl.edu (128.227.236.202)  21.151 ms  15.915 ms  23.419 ms
 9  ssrb230a-dcpopl3-7009-1-vdc2-v601-1.ns.ufl.edu (128.227.236.155)  33.039 ms  15.406 ms  15.769 ms
10  virtual-l2www-prod-ac-publicssl.server.ufl.edu (128.227.36.35)  23.838 ms  15.461 ms  16.224 ms
(base) jaswanth@jaswanths-MacBook-Air ~ %
```

Hour 3: traceroute ufl.edu

```
[(base) jaswanth@jaswanths-MacBook-Air ~ % traceroute ufl.edu
traceroute to ufl.edu (128.227.36.35), 64 hops max, 52 byte packets
 1  192.168.0.1 (192.168.0.1)  18.598 ms  3.103 ms  5.646 ms
 2  10.4.0.1 (10.4.0.1)  19.731 ms  12.783 ms  12.423 ms
 3  100.122.94.76 (100.122.94.76)  24.797 ms  13.444 ms  13.562 ms
 4  ip72-214-194-3.ga.at.cox.net (72.214.194.3)  21.237 ms  11.477 ms  11.142 ms
 5  wsip-184-188-101-187.at.at.cox.net (184.188.101.187)  26.141 ms  13.908 ms  16.631 ms
 6  ssrb230a-pel-asr9001-1-v16-1.ns.ufl.edu (128.227.236.204)  19.029 ms  11.861 ms  12.899 ms
 7  * * *
 8  ssrb230a-nexus-msfc-1-v15-1.ns.ufl.edu (128.227.236.202)  27.764 ms  16.278 ms  14.938 ms
 9  ssrb230a-dcpopl3-7009-1-vdc2-v601-1.ns.ufl.edu (128.227.236.155)  18.991 ms  15.655 ms  15.086 ms
10  presidentsearch.ufl.edu (128.227.36.35)  20.184 ms  13.935 ms  13.031 ms
(base) jaswanth@jaswanths-MacBook-Air ~ %
```

Question 7(d) – Inter – Continent Trace Route

Hour 1: traceroute modak.com

```
[(base) jaswanth@jaswanths-MacBook-Air ~ % traceroute modak.com
traceroute: Warning: modak.com has multiple addresses; using 104.21.80.192
traceroute to modak.com (104.21.80.192), 64 hops max, 52 byte packets
 1  192.168.0.1 (192.168.0.1)  21.875 ms  3.190 ms  4.038 ms
 2  10.4.0.1 (10.4.0.1)  45.705 ms  15.125 ms  10.538 ms
 3  100.122.94.76 (100.122.94.76)  21.826 ms  12.130 ms  8.723 ms
 4  100.122.93.64 (100.122.93.64)  27.079 ms  38.626 ms  51.295 ms
 5  gainhdrj01-ae1.0.rd.ga.cox.net (68.1.2.140)  49.670 ms  38.588 ms  39.758 ms
 6  141.101.73.251 (141.101.73.251)  53.837 ms  38.847 ms  43.166 ms
 7  141.101.73.18 (141.101.73.18)  52.833 ms  98.691 ms  41.291 ms
 8  104.21.80.192 (104.21.80.192)  50.855 ms  39.627 ms  37.593 ms
```

Hour 2: traceroute modak.com

```
[(base) jaswanth@jaswanths-MacBook-Air ~ % traceroute modak.com
traceroute: Warning: modak.com has multiple addresses; using 104.21.80.192
traceroute to modak.com (104.21.80.192), 64 hops max, 52 byte packets
 1  192.168.0.1 (192.168.0.1)  20.880 ms  9.313 ms  5.636 ms
 2  10.4.0.1 (10.4.0.1)  20.427 ms  17.327 ms  16.186 ms
 3  100.122.94.76 (100.122.94.76)  24.031 ms *  28.404 ms
 4  100.122.93.64 (100.122.93.64)  20.418 ms  17.751 ms  14.821 ms
 5  gainhdrj01-ae1.0.rd.ga.cox.net (68.1.2.140)  45.089 ms  36.366 ms  39.230 ms
 6  141.101.73.251 (141.101.73.251)  54.542 ms  40.597 ms  57.731 ms
 7  172.70.176.2 (172.70.176.2)  48.548 ms  42.422 ms
    172.70.124.2 (172.70.124.2)  296.873 ms
 8  104.21.80.192 (104.21.80.192)  49.952 ms  38.404 ms  38.835 ms
```

Hour 3: traceroute modak.com

```
[(base) jaswanth@jaswanths-MacBook-Air ~ % traceroute modak.com
traceroute: Warning: modak.com has multiple addresses; using 104.21.80.192
traceroute to modak.com (104.21.80.192), 64 hops max, 52 byte packets
 1  192.168.0.1 (192.168.0.1)  19.498 ms  3.096 ms  10.932 ms
 2  10.4.0.1 (10.4.0.1)  17.455 ms  10.950 ms  12.256 ms
 3  100.122.94.76 (100.122.94.76)  180.400 ms  14.902 ms  21.337 ms
 4  100.122.93.64 (100.122.93.64)  23.441 ms  11.958 ms  10.687 ms
 5  gainhdrj01-ae1.0.rd.ga.cox.net (68.1.2.140)  63.076 ms  38.867 ms  38.071 ms
 6  141.101.73.251 (141.101.73.251)  383.777 ms  44.515 ms  36.224 ms
 7  141.101.73.18 (141.101.73.18)  50.666 ms
    172.70.128.2 (172.70.128.2)  53.474 ms
    172.70.176.2 (172.70.176.2)  49.028 ms
 8  104.21.80.192 (104.21.80.192)  47.368 ms  37.963 ms  38.152 ms
```