CS & IT ENGINEERING

Computer Networks

Switching

Lecture No.- 03

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Recap of Previous Lecture

Topic circuit switching

Topic Packet switching

Topics to be Covered

Topic Problem solving on Packet switching

1 car ⟶ 4 days

100 car ⟶ 4×100 = 400 days

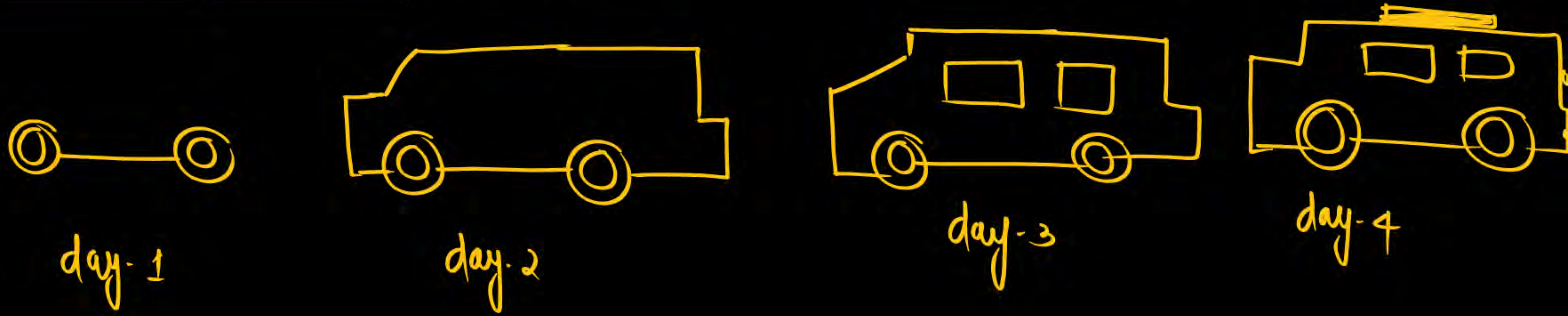
Pipelining concept

1 car - 4 days

99 car → 99 days

______

103 days



Problem Solving
On
Packet Switching

Topic : Packetization in packet switching:

- The process of dividing a single message into smaller size packet is called as packetization.
- These smaller size packets are sent one after other.
- It gives the advantage of pipelining and reduce the total time taken to transmit the message.

Topic : Problem solving on Packet Switching

#Q. Consider the store and forward packet switched network given below. Assume that the bandwidth of each link is 10^6 bytes/sec. A user on host A sends a file of size10^3bytes to host B through routers R1 and R2 in three different ways. In the first case a single packet containing the complete file is transmitted from A to B. In the second case, the file is split into 10 equal parts, and these packets are transmitted from A to B. In the third case, the File is split into 20 equal parts and the packets are sent from A to B. Each packet contains 100 bytes of header information along with the user data. Consider only transmission time and ignore processing, queuing and propagation delays. Also assume that there are no errors during transmission. Let T1, T2 and T3 be the times taken to transmit the file in the first, second and third case respectively. Which one of the following is correct?

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A. T1 < T2 < T3

B. T1 > T2 > T3

C. T2 = T3, T3 < T1

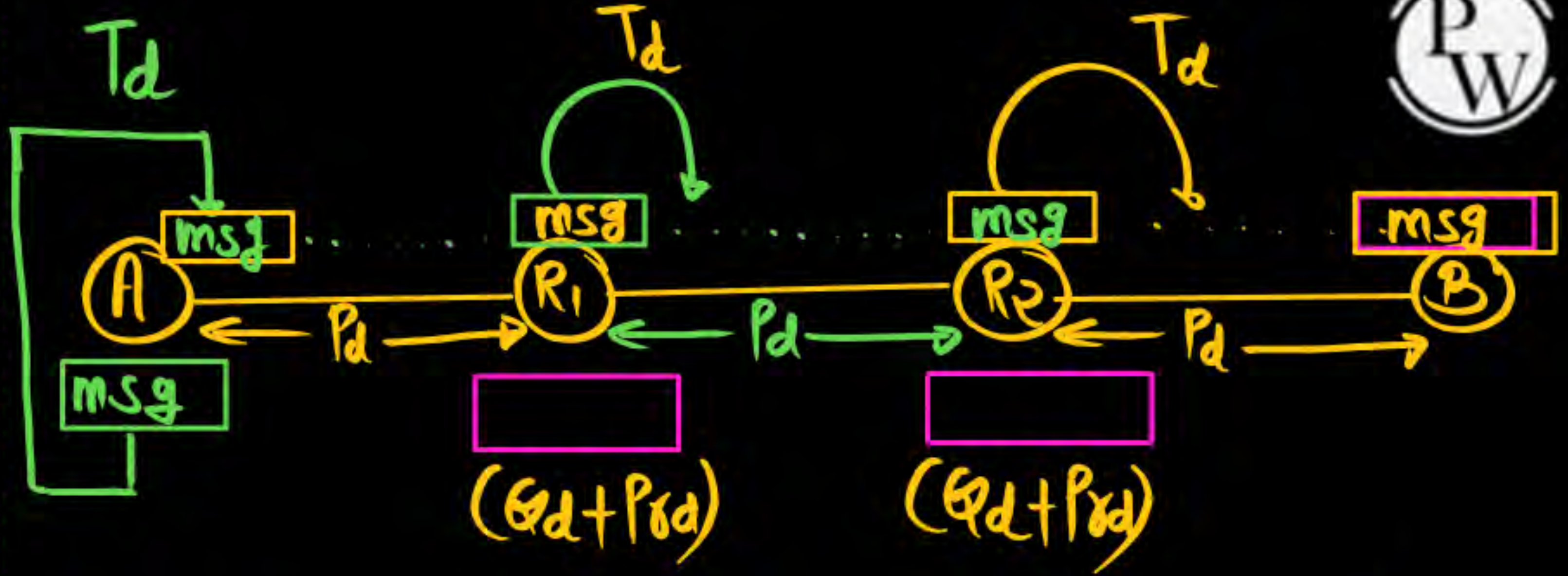
D. T1 = T3, T3 > T2

$B = 10^6$ Byte/sec

Header size = 100 Byte

File size = 10^3 Byte

= 1000 Byte



Total time $= X[T_d + \cancel{P_d}^{\,0}] + X-1\,(\cancel{Q_d}^{\,0} + \cancel{P_{rd}}^{\,0})$

$= 3 \times 1.1 = 3.3$ msec (T_1)

$\boxed{\text{Case I}}$

Packet size = data + Header

= 1000B + 100B

= 1100 Byte

$T_d(\text{Pkt}) = \dfrac{\text{Pkt size}}{\text{Bandwidth}} = \dfrac{1100\ \text{Byte}}{10^6\ \text{byte/sec}} = 11 \times 10^{-4}\ \text{sec}$

$= 1.1 \times 10^{-3}\ \text{sec} = 1.1\ \text{msec}$

Case II

Sending a File in 5 PKts

Data in each Packet $= \frac{1000B}{5} = 200B$

Header size = 100 Byte

One Packet size = Data + Header

$= 200 + 100 = 300$ Byte

$T_d(PKt) = \frac{PKt\ size}{Bandwidth}$

$= \frac{300\ Byte}{10^6\ Byte/sec} = 3 \times 10^{-4} = 0.3 \times 10^{-3}$

$= 0.3$ msec

Time taken to reach 1^{st} Packet From Source to Destination $= 3 * T_d = 3 * 0.3 = 0.9$ msec

Time taken to reach remaining 4 Packet From source to destination $= 4 * T_d$

$= 4 * 0.3 = 1.2$ ms

Total time $= 0.9$ msec $+ 1.2$ msec $= 2.1$ msec

Case III Sending a File in 10 PKts

Data in each PKt $= \frac{1000B}{10} = 100$ Byte

Header size $= 100$ Byte

One Packet size $=$ Data $+$ Header

$100 + 100B = 200$ Byte

$$T_d(PKt) = \frac{PKt\ size}{Bandwidth}$$

$$= \frac{200B}{10^6 B/sec}$$

$$= 2 * 10^{-4} sec = 0.2 * 10^{-3} sec$$

$$= 0.2\ msec$$

Time taken to reach 1st PKt From source to destination $= 3 * T_d = 3 * 0.2 = 0.6$

Time taken to reach remaining '9' PKt From source to destination $= 9 * T_d = 9 \times 0.2$

$= 1.8$ msec

Total time $= 0.6 + 1.8 = 2.4$ msec (T_2)

Case IV Sending a File in 20 Packets

Data in each Pkt = $\frac{1000B}{20}$ = 50B

Header size = 100B

One Packet = Data + Header
= 50B + 100B
= 150 Byte

$T_d(\text{Pkt}) = \frac{\text{Pkt size}}{\text{Bandwidth}}$

$= \frac{150B}{10^6\ B/\text{sec}} = 150 * 10^{-6}\ \text{sec}$

$= 0.15 * 10^{-3}$

$= 0.15\ \text{msec}$

Time taken to reach 1st Pkt From source to destination = $3T_d = 3 * 0.15 = 0.45$ msec

Time taken to reach remaining 19 Pkt From source to Destination $= 19T_d$

$= 19 * 0.15$

$= 2.85$ msec

Total time = 0.45 msec + 2.85 msec
= 3.3 msec (T_3)

T_1	T_2	T_3
3.3 ms	2.4 ms	3.3 ms

$$\boxed{T_1 = T_3 > T_2}$$

$$\boxed{T_2 < T_1 = T_3}$$

Case I	Case II	Case III	Case IV	Case V
single message	5 Pkts	10 Pkts	20 Pkt	30 Pkt
⇓	⇓ min	⇓	⇓	⇓
3.3 msec	2.1 msec	2.4 ms	3.3 ms	> 3.3 ms

Total No. of Pkts $= \dfrac{M}{p}$

$= \dfrac{1000\text{B}}{223.6\text{B}}$

$= 4.47 \approx 5$ Pkt

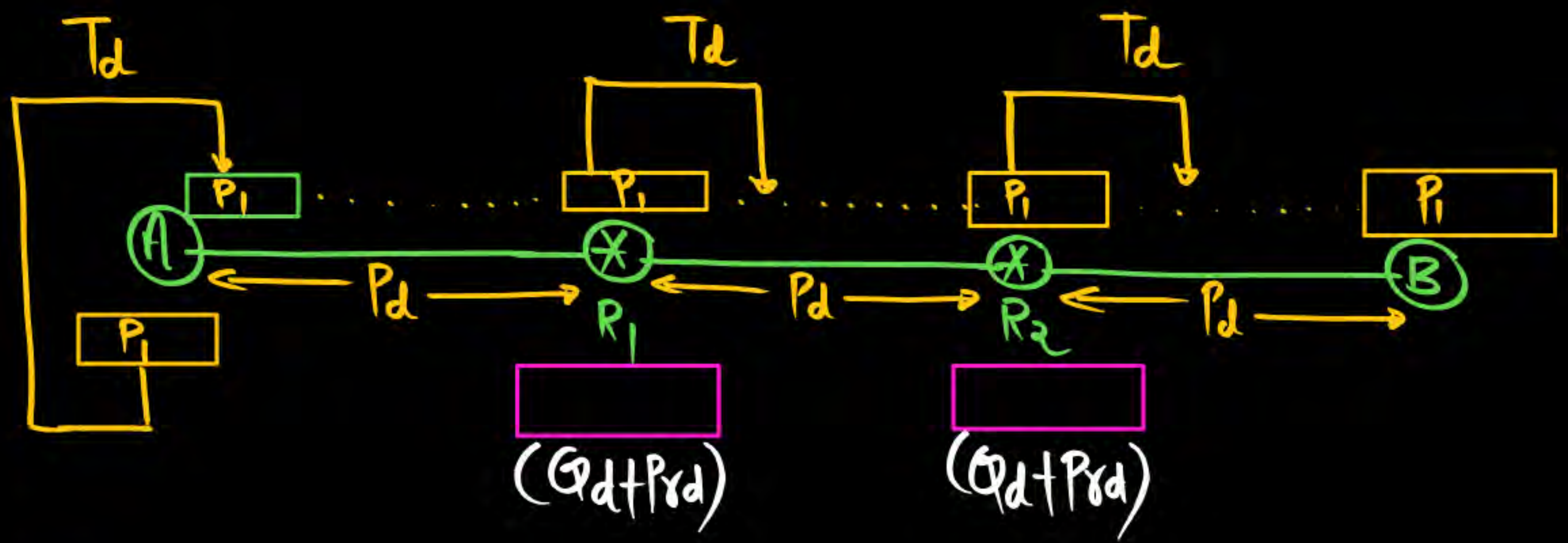
$$p = \sqrt{\frac{mh}{X-1}}$$

$$p = \sqrt{\frac{1000 \times 100}{3-1}}$$

$$p = \sqrt{50{,}000}$$

$p = 223.6$ Byte

Total time For X → Hop and 'N' PKts



Total time = Time taken to reach 1st PKt + Time taken to Remaining (N-1) PKt

$$\boxed{\text{Total time} = X[T_d + P_d] + (X-1)(Q_d + P_{rd}) + (N-1)(T_d)}$$ *****

Optimal Packet Size

If the packet size is not chosen properly then it might increase the total time taken to transmit the message. So it is very important to choose the packet size properly.

Topic : Optimal Packet Size

Generalized Formula for optimal packet size

Suppose

M = Message size

h = Header size

p = Payload/Packet data size

assume bandwidth is 'b' bits/sec

Number of Hops = X

Total No. of Packet = M/p

Packet size (P) = $p + h$

Topic : Optimal Packet Size

When message is Packetized then these are send in a pipelined manner to reduce transmission time but there is a threshold on packet size 'P' Hence it may not be more large or more small It must be optimum.

"Now we first derive transmission delay (1st packet takes transmission delay by all the intermediate nodes and source or transmission delay on all hopes and rest all packet take only one hope transmission delay due to pipeline)

1st Pkt

Topic : Optimal Packet Size

Transmission time(TT) $= \left(\frac{p+h}{b}\right) X + \left(\frac{M}{p} - 1\right)\left(\frac{p+h}{b}\right)$

$$= \frac{1}{b}\left[(p+h)\,X + \frac{1}{p}(M-p)(p+h)\right]$$

So resultantly we want to find minimum transmission delay at optimum packet size so differentiate TT w.r.t 'p' we get

$$\frac{d}{dp}TT = \frac{1}{b}\left(X * p^2 - p^2 - Mh\right) = 0$$

so $$p^2 = \left(\frac{Mh}{X-1}\right)$$

$$\text{p} = \sqrt{\frac{Mh}{X-1}}$$

So optimum packet size $\boxed{P = p + h}$

Topic : Problem solving on Packet Switching

#Q. In a packet switching network, packets are routed from source to destination along a single path having two intermediate nodes. If the message size is 24 bytes and each packet contains a header of 3 bytes, then the optimum packet size is:

A. 4

B. 6

C. 7

D. 9

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No. of Hops (X) = 3

S — R_1 — R_2 — D

Message size = 24 Byte

Header size = 3 Byte

$$p = \sqrt{\frac{mh}{X-1}}$$

$$= \sqrt{\frac{24 \times 3}{2}}$$

$$p = \sqrt{36}$$

$$p = 6$$

$$\text{Packet size } (P) = p + h$$

$$= 6 + 3 = 9$$

Total No. of Pkts $= \frac{M}{P}$

$$= \frac{24\cancel{B}}{6\cancel{B}} = 4$$

Topic : Problem solving on Packet Switching

#Q. Consider a source computer (S) transmitting a file of size 10^6 bits to a destination computer (D) over a network of two routers (R1 and R2) and three links (L1, L2 and L3). L1 connects S to R1, L2 connects R1 to R2 and L3 connects R2 to D. Let each link be of length 100 km. Assume signals travel over each link at a speed of 10^8 meters per second. Assume that the link bandwidth on each link is 1 Mbps. Let the file be broken down into 1000 packets each of size 1000 bits. Find the total sum of transmission and propagation delays in transmitting the file from S to D?

A. 1005 ms

B. 1010 ms

C. 3000 ms

D. 3003 ms

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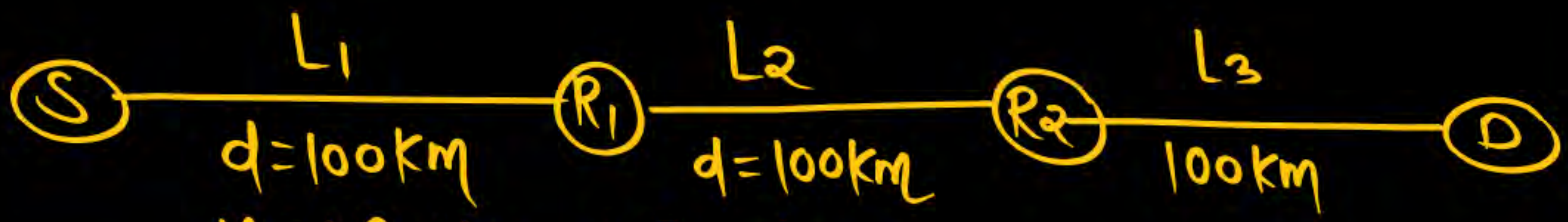
File size $= 10^6$ bits , $X = 3$



$v = 10^8$ m/sec $= 10^5$ km/sec

$B = 1$ mbps $= 10^6$ Bits/sec

No. of Pkts (N) = 1000

Pkt size = 1000 bits

For X → Hop and N → Pkts

Total time $= X[T_d + P_d] + X - 1(\cancel{Q_d + P_{rd}}) + (N-1)T_d$

0

$= 3[1+1] + 999 * 1$

$= 6$ msec $+ 999$ msec $= 1005$ msec

$P_d = \dfrac{d}{v}$

$P_d = \dfrac{100\,km}{10^5\,km/sec} = 10^{-3}\,sec = 1\,msec$

$T_d(pkt) = \dfrac{\text{Pkt size}}{\text{Bandwidth}}$

$= \dfrac{1000\,bits}{10^6\,bits/sec} = 10^{-3}\,sec$

$= 1\,msec$

Topic : Problem solving on Packet Switching

#Q. Two hosts are connected via a packet switch with 10^7 bits per second links. Each link has a propagation delay of 20 microseconds. The switch begins forwarding a packet 35 microseconds after it receives the same. If 10000 bits of data are to be transmitted between the two hosts using a packet size of 5000 bits, the time elapsed between the transmission of the first bit of data and the reception of the last bit of the data in microseconds is 1575.

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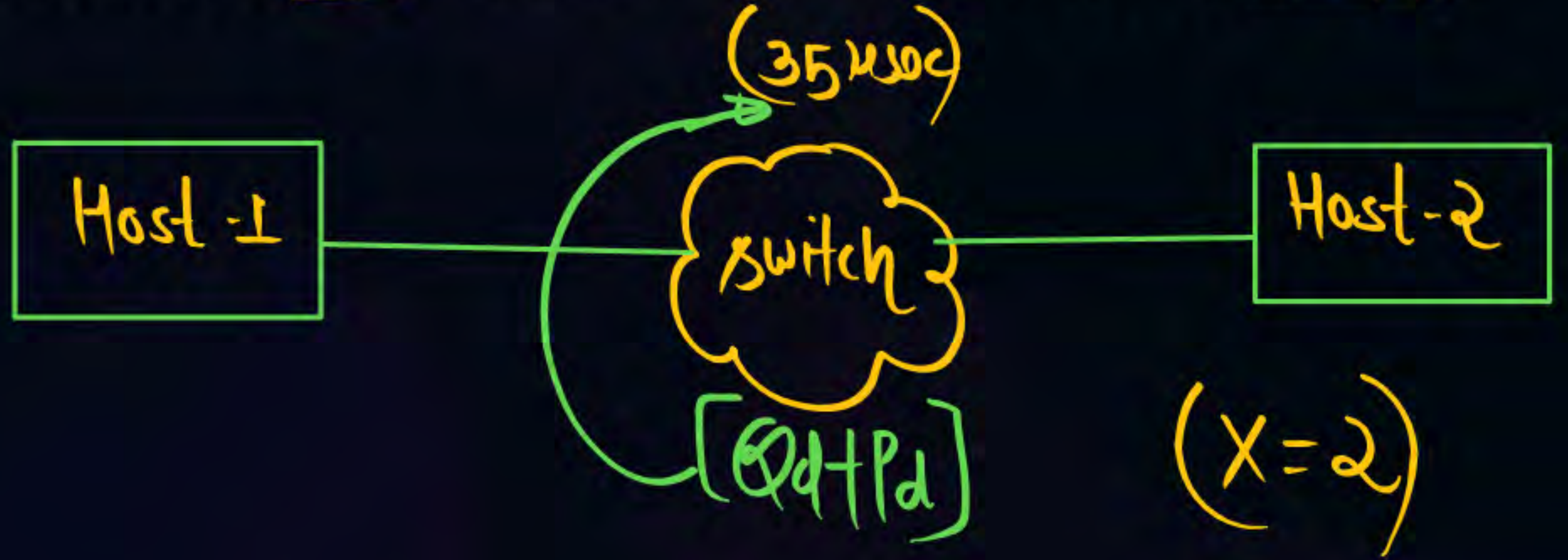

$B = 10^7$ bits/sec

$P_d = 20\mu sec$

Slide 31

$\text{Pkt size} = 5000 \text{ bits}$

$\text{No. of Pkts } (N) = \dfrac{10000 \text{ bits}}{5000 \text{ bits}} = 2$

$T_d(\text{Pkt}) = \dfrac{\text{Pkt size}}{\text{Bandwidth}} = \dfrac{5000 \text{ bits}}{10^7 \text{ bits/sec}}$

$= 500 \times 10^{-6} \text{ sec} = 500 \mu s$

$$\text{Total time} = X[T_d + P_d] + X-1(Q_d + P_{rd}) + N-1(T_d)$$

$$= 2[500 + 20] + 1 \times 35 + (2-1) \times 500$$

$$= 1000 + 40 + 35 + 500$$

$$= 1575 \mu sec$$

Topic : Problem solving on Packet Switching

#Q. Suppose two hosts are connected through two intermediate switches.

$H_A \rightarrow$ Switch $\rightarrow$ Switch $\rightarrow H_B$ $(x = 3)$

Suppose each link (one way) propagation delay is 20 ms and each link data transfer rate is 1 Mbps. If packet size is 1000 Bytes then the amount of time required to send one file of size 5000 Bytes from sender to receiver (Consider for processing overhead at switch is negligible) is ______ .

$P_d = 20\,\text{msec}$, $B = 10^6\ \text{bits/sec}$, Pkt size = 1000 Byte, File size = 5000 Byte

$T_d(\text{Pkt}) = \dfrac{\text{Pkt size}}{\text{Bandwidth}} = \dfrac{8\cancel{000}\ \text{bits}}{10^{\cancel{6}}\ \text{bits/sec}}$

$= 8 \times 10^{-3}\ \text{sec} = 8\ \text{msec}$

No. of Packets $(N) = \dfrac{5\cancel{000}\ B}{1\cancel{000}\ B} = 5$

Slide 32

$$\text{Total time} = X\,[T_d + P_d] + (X-1)\,\underbrace{\cancel{[Q_d + P_{rd}]}}_{0} + (N-1)\,T_d$$

$$= 3\,[8 + 20] + 4 * 8$$

$$= 24 + 60 + 32$$

$$= 84 + 32 = 116 \text{ msec}$$

#Q. Consider two hosts A and B are connected through two routers R_1 and R_2. H.W

Each link has propagation delay (one way) 20 ms, data transfer rate is 1 Mbps and processing delay at each router is 2 ms. Host A uses pipeline protocol for flow control. The time required (in ms) to transmit a file of size 12000 Bytes from host A to host B, using packet size 1000 Bytes is (176 msec)

Topic : Problem solving on Packet Switching

(XXXXX)

#Q. Consider a host computer (A) transmitting a file of size 10^5 bits to a host computer (B) over a network of routers (R_1, R_2, ... R_n) and links (L_1, L_2, ... L_n). L_1 connect A to R_1; L_2 connect R_1 to R_2. L_3 connect R_2 to R_3 and L_n connect R_{n-1} to B. Let each link be of length 100 km. Assume signals travel over each link at a speed of 10^8 meter per second. Let the file be broken down into 100 packets of each of size 1000 bits. Assume bandwidth on each links is 1 Mbps. The total sum of transmission delay and propagation delay in transmitting the file from A to B is 119 msec. Assume Y is number of routers between A and B, and X is number of minimum links between A and B then find x + y? Ans: 19

2 mins Summary

Topic One Packet Switching

Topic Two Circuit Switching

Topic Three

Topic Four

Topic Five

THANK - YOU