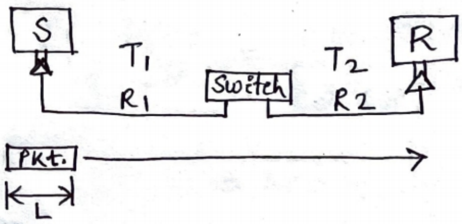
Numerical Problems & Solutions
on
Packet Switched Delay, Datarate & Bandwidth Calculations

1. Suppose there is exactly one packet switch between a sending host and a receiving host. The transmission rates between the sending host and the switch and between the switch and the receiving host are R1 and R2 , respectively. What is the total end-to-end delay to send a packet of length L? (Ignore queuing, propagation delay, and processing delay.)

Solution :-

Assumptions : Ignore Queuing delay, Propagation delay & Processing delay



Here, total time, $T = T_1 + T_2$

$$\text{Packet Transmission time} = \frac{\text{Packet Size}}{\text{Datarate}} = \frac{L}{R}$$

$$\text{Therefore, } T = \frac{L_1}{R_1} + \frac{L_2}{R_2} = \frac{L}{R_1} + \frac{L}{R_2} = \frac{L(R_1+R_2)}{R_1 \cdot R_2},$$

here $L1 = L2 = L$

$$\text{So, Total end to end delay, } T = \frac{L(R_1+R_2)}{R_1 \cdot R_2}$$

2. How long does it take a packet of length 1,000 bytes to propagate over a link of distance 2,500 km, propagation speed 2.5*10^8 m/s, and transmission rate 2Mbps? Does this delay depend on packet length? Does this delay depend on transmission rate?

Solution :-

Assumptions : Queuing delay and processing delay are ignored.

So, Total delay $(T_{total}) = T_p + T_{fr}$,

where T_p is propagation delay and T_{fr} is packet transmission delay

$$T_p = \frac{\text{Distance}}{\text{Propagation speed}} = \frac{2500 \times 10^3 \ m}{2.5 \times 10^8 \ m/s} = 10^{-2} s = 10 \ ms$$

$$T_{fr} = \frac{\text{Packet Size}}{\text{Data rate}} = \frac{1000 \text{ bytes}}{2 \text{ Mbps}} = \frac{1000 \times 8 \text{ bits}}{2 \times 10^6 \text{ bits/sec}} = 4 \times 10^{-3} s = 4 \ ms$$

$$\text{So, } T_{total} = T_p + T_{fr} = (10+4) \ ms = 14 \ ms$$

3. Consider a packet of length 1,500 bytes which begins at end system A and travels over three links to a destination end system. These three links are connected by two packet switches, the propagation speed on all the links is 2.5*10^8 m/s, the transmission rates of all three links are 2 Mbps, the packet switch processing delay is 3 msec, the length of the first link is 5,000 km, the length of the second link is 4,000 km, and the length of the last link is 1,000 km. For these values, what is the end-to-end delay?

Solution :- Given that Propagation delay $(T_P) = 2.5 \times 10^8$ m/s

Packet transmission time $(T_{fr}) = \dfrac{\text{Packet size}}{\text{Datarate}} = \dfrac{1500 \times 8 \text{ bits}}{2 \times 10^6 \text{ bits/sec}}$

$= 6 \times 10^{-3}$ s $= 6$ ms

$$T_{P1} = \frac{\text{Distance}}{\text{Speed}} = \frac{5000 \times 10^3 \text{ m}}{2.5 \times 10^8 \text{ m/s}} = 20 \text{ ms}$$

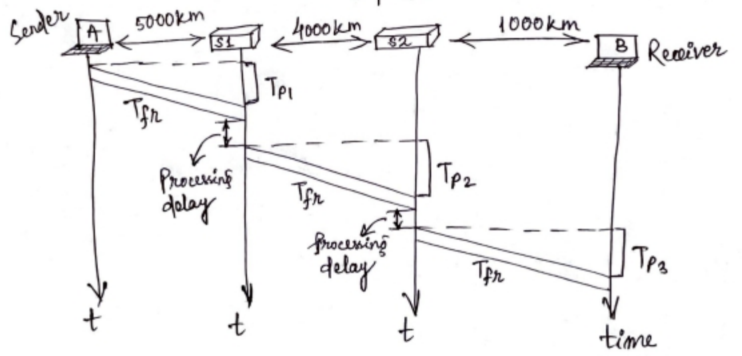
$$T_{P2} = \frac{4000 \times 10^3 \text{ m}}{2.5 \times 10^8 \text{ m/s}} = 16 \text{ ms}$$

$$T_{P3} = \frac{1000 \times 10^3 \text{ m}}{2.5 \times 10^8 \text{ m/s}} = 4 \text{ ms}$$

$$\text{Total delay } (T_{total}) = 3T_{fr} + T_{P1} + T_{P2} + T_{P3} + (2 \times \text{Processing delay})$$

$$= (3 \times 6\text{ms}) + 20\text{ms} + 16\text{ms} + 4\text{ms} + (2 \times 3\text{ms})$$

$$= 64 \text{ ms}$$

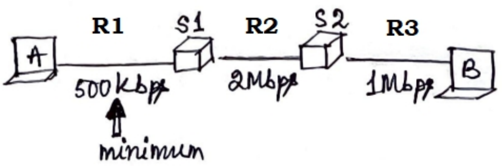


4. Suppose Host A wants to send a large file to Host B. The path from Host A to Host B has three links, of rates R 1 = 500 kbps, R 2 = 2 Mbps, and R 3 = 1Mbps. Assuming no other traffic in the network, what is the throughput for the file transfer.

Solution:-

Throughput is effective datarate.

In this case, throughput for the file transfer is 500 Kbps.



Note :- for serial links throughput is the minimum rate and for parallel links throughput is the addition of all rates.

5. Consider a point-to-point link 50 km in length. At what bandwidth would propagation delay (at a speed of 2*10^8 m/s) equal transmit delay for 100-byte packets?

Solution :- We know propagation delay $(T_p) = \dfrac{\text{Distance}}{\text{Speed}} = \dfrac{50\,Km}{2\times10^8\,m/s}$

$$= \frac{50 \times 10^3\,m}{2\times 10^8\,m/s} = 2.5\times10^{-4}\,s$$

$$= 0.25\ ms$$

The packet transmission time (T_{fr}) = Packet size / Datarate (or Bandwidth)

$$= \frac{100\text{ bytes}}{\text{Bandwidth (BW)}}$$

According to the question, the condition is $T_p = T_{fr}$

$$\Rightarrow 0.25\,ms = \frac{100\text{ bytes}}{BW}$$

$$\Rightarrow \text{Bandwidth (BW)} = \frac{100\times 8\,bits}{0.25\times10^{-3}\,sec.}$$

$$= 32\times10^5\ b/s$$
$$= 3.2\times10^6\ b/s$$
$$= 3.2\ Mbps$$

6. Suppose N packets arrive simultaneously to a link at which no packets are currently being transmitted or queued. Each packet is of length L and the link has transmission rate R. What is the average queuing delay for the N packets?

Solution :- Given that the packet arrival rate = N packets/sec.

Packet length = L bits

Link Transmission rate = R bits/sec.

Note :- The queuing delay for 1st packet is 0.
for 2nd " is L/R
for 3rd " is $2L/R$
for nth " is $(n-1)\,L/R$.

The average queuing delay is $\dfrac{1}{N}\sum_{n=1}^{N}(n-1)\,L/R$

$$= \frac{L}{R}\frac{1}{N}\sum_{n=0}^{N-1} n = \frac{L}{R}\frac{1}{N}\frac{(N-1)N}{2} = \left(\frac{N-1}{2}\right)\frac{L}{R}$$

7. Suppose two hosts, Aand B, are separated by 20,000 kilometers and are connected by a direct link of R = 2 Mbps. Suppose the propagation speed over the link is 2.5*10^8 meters/sec.
   a. Calculate the bandwidth-delay product, i.e., R*propagation delay.
   b. Consider sending a file of 800,000 bits from Host A to Host B. Suppose the file is sent continuously as one large message. What is the maximum number of bits that will be in the link at any given time?

Solution :-

Note :- The Bandwidth-Delay Product is used to design buffer size of the intermediate devices like Routers/ Switches in network. And if a file is sent continuously as one message then a link can have the maximum number of bit which is same as Bandwidth-delay-product.

Usually, Bandwidth-delay product is $R \times RTT$ and $RTT = 2 \times T_P$, where T_P is propagation delay.

But for single way data transmission, Bandwidth-delay product is $R \times T_P$

(a) Bandwidth-delay product = R × Propagation delay

$$= R \times \frac{\text{Distance}}{\text{Speed}} = 2\,\text{Mbps} \times \frac{20{,}000\ \text{Km}}{2.5 \times 10^8\ \text{m/s}}$$

$$= (2 \times 10^6\ \text{b/s}) \times (8 \times 10^{-2}\ \text{s})$$

$$= 16{,}0000\ \text{bits} = 16 \times 10^4\ \text{bits}$$

(b) As mentioned in the note above, 16,0000 bits will be in the link at any given time.

=======================End of Solution========================

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