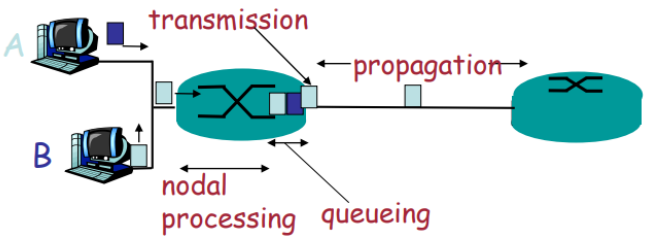
Assignment 1 - Solution

Covered Topics:-
Network Delays

Four Sources of Packet Delay

1. Processing Delay (D_{Proc})
2. Queuing Delay (D_{Queue})
3. Propagation Delay (D_{Prop})
4. Transmission Delay (D_{Trans})



Total End-to-End Delay

$$D_{Nodal} = D_{Proc} + D_{Queue} + D_{Trans} + D_{Prop}$$

Where

D_{Trans}= L/R

L= Length of packet (bits)

R = Link bandwidth (bps)

D_{Prop}= d/s

d= Length of physical link

s= Propagation speed in medium (~$2x10^8$ m/sec)

Units Conversions:-

1 Byte (B) = 8 bits (b)
1 Kbps = $1x10^3$ bps
1 Mbps = $1x10^6$ bps
1 Gbps = $1x10^9$ bps
1 msec= $1x10^{-3}$ sec

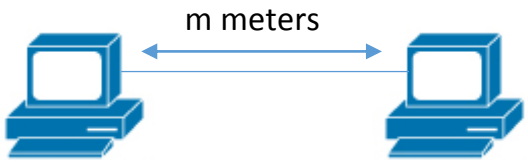
Problem 1

Consider two hosts, A and B, connected by a single link of rate R bps. Suppose that the two hosts are separated by m meters, and suppose the propagation speed along the link is s meters/sec. Host A is to send a packet of size L bits to host B.

- Express the propagation delay d_{prop} in terms of m and s.
- Express the transmission delay d_{trans} in terms of L and R.
- Ignoring processing and queuing delays, what will be the total end-to-end delay?
- Suppose $s = 2.5*10^8$ m/S, L= 1500 bits, and R = 28 Kbps. Find the distance m so that d_{prop} equals d_{trans} .

Solution:-

- D_{Prop}= d/s seconds.
- D_{trans} = L / R seconds.
- $D_{end-to-end}$ = (d/s + L/R) seconds.
- $D_{Prop} = D_{trans}$



d / s = L / R
m / $2.5x10^8$ = 1500 / $28x10^3$
m = (1500 / $28x10^3$) ($2.5x10^8$)
m = $134x10^5$ m

Problem 2

Consider a point-to-point link 100 km in length. The propagation speed of bits in this link is $2*10^8$ m/s. At what bandwidth will propagation delay equal transmission delay for a 100 bytes packets?

Solution:-

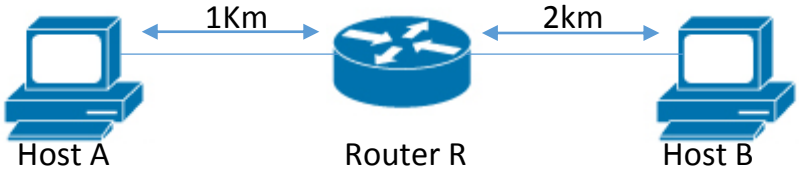
According to the given

$D_{Prop} = D_{trans}$
d / s = L / R
$100x10^3$ / $2x10^8$ = 100 x 8 / R
R = 800 x ($2x10^8$/$100x10^3$) = $16x10^5$ bps

Problem 3

Host A wants to send a 1Mbyte packet to Host B. The propagation speed of bits is $2*10^8$ m/sec. Assume that A and B are connected via a router R. Link AR connects A to R, and link RB connects R to B. Link AR is 1Km long and link RB is 2Km long. Suppose that the capacity of each of the 2 links is 10 Mbytes/sec and the processing delay in the Router (R) is 10 msec. Find after how long will host B receive the packet. Note the Router (R) must receive the whole packet before being able to forward it.

Solution:-



In order to compute the total delay we will break it down into:

Total delay = Delay from host A to router R + Delay at the router + Delay from router R to host B

Delay A-> R = Transmission delay + Propagation delay

= ($1x10^6$ b / 10 $x10^6$ bps) + (10^3 m / $2x10^8$ m/s)

= 0.1 s + $0.5x10^{-5}$ s = 100.005 ms

Delay from R-> B = Transmission delay + Propagation delay

= ($1x10^6$ b / 10 $x10^6$ bps) + ($2x10^3$ m/ 2x108 m/s)

= 100.01 ms

Total delay = 100.005 ms + 10 ms + 100.01 ms = 210.015 ms.

Problem 4

A system has an n-layer protocol hierarchy. Applications generate messages of length M bytes. At each of the layers an h-byte header is added. What fraction of the network bandwidth is filled with headers?

Solution:-

Each message is M-bytes long. There are n-layers each one adding an h-byte header, therefore, each message that is transmitted through the network is (nh+M) bytes long. The fraction of the network bandwidth that is filled with headers is given by nh / (nh+M).

If it is assumed that the bottom layer (physical) does not generate any header, then there shall be (n-1) h headers generated, so the fraction of the network bandwidth that is filled with headers is given by (n-1) h / [(n-1) h+M.

Problem 5

Host A needs to ping Server B to make sure that it is connected, assuming that the distance between Host A and Server B is 5 KMs, the speed of bits in the wire is $2*10^8$ m/s, and the bandwidth is 20 Mbps, assuming that an Echo Request message is 80 MBytes and an Echo Response is 100 MBytes, then how long would each message take to be sent and received by Host A.

Solution:-

Total delay = Total Delay echo request from A -> B + Total Delay echo reply from B -> A

$= (Delay_{propAB} + Delay_{TransAB}) + (Delay_{propBA} + Delay_{TransBA})$

$= [(5x10^3/2x10^8) + (80x8x10^6)/20\ x10^6)] + [(5x10^3/2x10^8) + (100x8\ x10^6)/20\ x10^6)]$

$= [(2.5x10^{-5}) + 32] + [(2.5x10^{-5}) + 40] = [32.0000.25] + [40.0000.25]$

$= 72.00005$ sec ≈ 72 sec.