Computer Networks: Homework #1

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Problem 1

Suppose users share a 20 Mbps link. Also suppose each user transmits continuously at 2 Mbps when transmitting, but each user transmits only 20 percent of the time.

1. When circuit switching is used, how many users can be supported?
2. For the remainder of this problem, suppose packet switching is used. Under what conditions will there be essentially no queuing delay before the link.
3. Suppose now there are 15 users. Find the fraction of the time that the queue grows.

Solution

Part A

In circuit switching, the resources are reserved for the duration of communication between the end systems.
$\therefore$ Total number of user supported $= \frac{20Mbps}{2Mbps} =$ **10 Users**

Part B

The bandwidth of the shared link is 20Mbps and as seen above, total number of user supported in circuit switching are 10. In packet switching, resources are not reserved. So when there are 10 or less users simultaneously active, the aggregate rate will be less than 20Mbps and thus, there will essentially be no queuing delay before the link.
Queuing will start if the aggregate rate goes above 20Mbps.

Part C

Suppose now there are 15 users. It is greater than the number of users that can simultaneously transmit without packet queuing. Thus, the queue will grow and the fraction of the time that the queue grows is,

$$= \sum_{x=11}^{15} \binom{15}{x} \cdot (0.2)^x \cdot (0.8)^{15-x}$$

$$= 0.000012461703168$$

$\therefore$ **The fraction of the time that the queue grows is 0.000012461703168.**

Problem 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 a transmission rate 2 Mbps. More generally, how long does it take a packet of length L to propagate over a link of distance d, propagation speed s, and transmission rate R bps? Does this delay depend on packet length? Does this delay depend on transmission rate?

Solution:

Distance: 2500km = $2.5 * 10^6$ m
Propagation speed: $2.5 * 10^8$ m/s
Length of the packet: 1000 bytes = $8 * 10^3$ bits
Transmission rate: 2 Mbps = $2 * 10^6$ bps

The question specifically asks for the propagation delay.
Propagation Delay (Time taken to travel the distance), d_{prop}: $\frac{2.5*10^6}{2.5*10^8}$ = 0.01 secs

$\therefore$ **Total time = d_{prop} = 0.01 secs**

More generally, the time for a packet of length L to **propagate** over a link of distance d, propagation speed s, and transmission rate R bps is given by $\frac{d}{s}$

No, this delay does not depend on either packet length or the transmission rate.

Problem 3

Suppose two hosts, A and B, are separated by 20,000 kilometers and are connected by a direct link of R = 2Mbps. Suppose the propagation speed over the link is $2.5 * 10^8$ m/sec.

1. Calculate the bandwidth-delay product, $R * d_{prop}$
2. 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?
3. What is the width (in meters) of a bit in the link?

Solution

Distance between host A and B = 20,000 Kms = $2 * 10^7$ m
Propagation speed: $2.5 * 10^8$ m/s
Transmission rate, R = 2 Mbps = $2 * 10^6$ bps

Propagation Delay (Time taken to travel the distance between host A and B), d_{prop}: $\frac{2*10^7}{2.5*10^8}$ = 0.08 Secs

Part A
Bandwidth-delay product = $R * d_{prop}$ = 2*10^6 * 0.08 = $\mathbf{1.6 * 10^5}$ **bits**

Part B
Size of the file: 800,000 bits.
As the file is sent continuously as one large message, there is only one packet.
$\therefore$ The packet length is $8 * 10^5$ bits.

Bandwidth-delay product is the maximum number of bits that can be in the link.
$\therefore$ The maximum number of bits that will be in the link at any given time,
= **min**[**packet_length**, **bandwidth_delay product**]
= min[$8 * 10^5$, $1.6 * 10^5$]
= $\mathbf{1.6 * 10^5}$ **bits**

Part C
As seen above, the maximum number of bits that can be in the link = bandwidth-delay product.

Thus, width of a bit in the link = $\frac{Length\ of\ the\ link}{bandwidth-delay\ product}$ **=** $\frac{2*10^7}{1.6*10^5}$ **= 125m**

Problem 4

Calculate the time that it takes to transmit 30000 bits of data across a 100Mbps Ethernet with store-and-forward switch in the path. Assume that each link introduces a propagation delay of 25 ms. Also assume the maximum segment size of 1500 bytes for an Ethernet frame.

Solution

Bits of data to be transmitted: 30000 bits
Transmission rate, R = 100Mbps = $10 * 10^7$ bps
Propagation delay, d_{prop} = 25ms per link
Segment size (packet length) = 1500bytes = 12000 bits
Total number of packets, P: (30000 / 12000) + 1 = 3

Assuming that there is only one router between the end systems, total number of links (N) = 2
$\therefore$ Total propagation delay, $d_{prop_t} = 25 * 2 * 3 = 150$ms

Time to send P packets over a path consisting of N links (N-1 routers) where each packet is L bits and the transmission rate is R bits/sec i.e. Transmission delay, d_{trans_t} is,

$= \frac{P*N*L}{R}$

$= \frac{2*2*12000}{10*10^7} + \frac{2*6000}{10*10^7}$

$= 6 * 10^{-4}$ secs = 0.6ms

$\therefore$ **Total time = $\mathbf{d_{trans_t} + d_{prop_t} = 150 + 0.6 = 150.6}$ms**