Yasir Aslam Shah

Problem Set #1

Assume that 1 Mbps = 10^6/ sec, 1 Gbps = 10^9 bit/sec, and 1MB = 10^6 x 8 bits. The capital 'B' typically means 'byte' while the lowercase 'b' indicates 'bit'.

1. **(3pts) What advantage does a circuit-switched network have over a packet-switched network?**

    - The advantage of circuit switching is its guaranteed performance as circuit switching has the advantage of having a dedicated circuit link without sharing (guaranteed performance).
    - Packet-Switching uses TDM or FMD. TDM has the advantage of being capable to use all the bandwith (multiplexing).

2. **(3pts) What advantage does TDM have over FDM in a circuit switched network?**

    - **TDM has** the **advantage** of being capable to use all the bandwith (multiplexing)
    - **No preallocation of resource hence resource wastage is less as resource will not be wasted on inactive users**

3. **(21pts) Consider two hosts, A and B, which are connected by a link (R bps). Suppose that the two hosts are separated by m meters, and the propagation delay along with link is s meters/sec. Host A is to send a packet of size L bits to Host B.**

    a. **Express the propagation delay, d_{prop}, in terms of m and s.**

    Propagation Delay is d_{prop}= **m/s**

b. **Determine the transmission time of the packet, d_{trans}, in terms of L and R**

transmission time of the packet d_{trans} is **L/R**

c. **Ignoring processing and queuing delays, obtain an expression for the end-to-end delay.**

End to end delay = transmission time + propagation delay + processing delay + queuing delay
as per question, processing delay=0 and queuing delay=0

end to end delay = transmission time + propagation delay
= (L/R + m/s)

d. **Suppose Host A begins to transmit the packet at time t = 0, At time t = d_{trans}, where is the last bit of the packet?**

The last bit just left the Host A

e. **Suppose d_{prop} is greater than d_{trans} . At time t = d_{trans}, where is the first bit of the packet?**

The first bit of the packet is traveling towards the Host B but hasn't reached Host B at all as d_{prop} is greater than d_{trans}

f. **Suppose d_{prop} is less than d_{trans} . At time t = d_{trans}, where is the first bit of the packet?**

The first bit of the packet has reached Host B as d_{prop} is less than d_{trans} .

g. **Suppose s = 2.5 * 10^8, L = 120bits, and R = 56kbps. Find the distance m so that d_{prop} equals d_{trans}.**

S = 2.5 * 10^8
L = 120bits
R = 56kbps

distance (m) as $d_{prop} = d_{trans}$
m/s=L/R
m=(L/R)xs
m=(120x2.5x10^8)/(56x10*1000)

m= **535714.28metres** or **535.57km**

4. **(8pts) We consider sending real-time voice from Host A to Host B over a packet-switched network. Host A converts analog voice to a digital 65kbps bit stream and send these bits into 56-byte packets. There is one link between Hosts A and B and the transmission rate is 1 Mbps and its propagation delay is 20 msec. As soon as Host A gathers a packet, it sends it to Host B. As soon as Host B receives an entire packet, it converts the packet's bits into an analog signal. How much time elapses from the time a bit is created (from the original analog signal at Host A) until the bit is decoded (as part of the analog signal at Host B)?**

Transmission Time= (56x8)10^6
Propagation Delay= 20ms
Conversion Delay= (56x8)/(65x1000)

Total time = Transmission Time + Propagation Delay + Conversion Delay
= (56x8)10^6 +20ms + (56x8)/(65x1000)
= 0.448ms + 20ms + 6.892ms
= 27.34msec
= 0.02734s

5. **(12pts) Users share a 15 Mbps link. Each user requires 150 Kbps when transmitting, but each user transmits only 10 percent of the time.**

   a. **When circuit switching is used, how many users can be supported?**
      Total number of user = Bandwidth/User Requirement

=15Mbps/150Kbps

=100 Users

Total number of user is 100

b. **When packet switching is used, what is the probability that a given user is transmitting?**

Probability = 10 percent

=0.1

c. **Suppose that there are 20 users. What is the probability that at any given time, exactly half of the users are transmitting simultaneously (Hint: Use the binomial distribution).**

$N!/(k!(n-k)!)^* p^k(1-p)^{(n-k)}$

user n=20

k=10

probability $=20!/(10!(20-10)!)^*(0.1)^{10}(1-0.1)^{(20-10)}$

$=184756^*(0.1)^{10}(1-0.1)^{(20-10)}$

$\mathbf{=6.44\ x10^{-6}}$

6. **(12pts) Suppose a 1-Gbps point-to-point link is being set up between the Earth and a new lunar colony. The distance from the moon to the Earth is approximately 385,000 km, and data travels over the link at the speed of light—3×10^8 m/s.**

a. **Calculate the minimum RTT for the link.**

Bandwidth=1-Gbps

Distance = 385,000km

speed of light = 3×10^8 m/s

Minimum RTT = (2x Distance)/Speed

= (2x 385000 x 1000)/(3x$10^{8)}$

= 2.566seconds

b. **Using the RTT as the delay, calculate the delay × bandwidth product for the link.**

Delay =2.566seconds

Bandwidth = 1Gbps

Bandwidth Product = Delay x Bandwidth

= 1Gbps x 2.566

= 320.75MB

= 2566Mb

c. **What is the significance of the delay × bandwidth product computed in (b) ?**

Bandwidth Product is the amount of data that can be transmitted in the network at a time before which the sender waits for the acknowledgement of the sent files from the receiver

7. **(8pts) What is the throughput when retrieving a 2MB file across a 1Gbps network with a round trip time of 300msec, again ignoring ACKs?**

a. **Assuming that the file transfer has to be initiated by the request.**

RTT =300msec

Ignoring ACKs as per Question

Size =2MB

Network Bandwidth =1Gbps

Transit Time=Size/Bandwidth

=2MB/1Gbps

=16msec

Throughput =(Size)/(RTT + Transit Time)

=2MB/(300msec +16msec)

=50.632Mbps

b. **Otherwise.**

Throughput =(Size)/((RTT)/2 + Transit Time)

$=2MB/(150msec + 16msec)$

=96.3855Mbps

8. **(5pts) Determine the width of a bit on a 10 Gbps link. Assume a copper wire, where the speed of propagation is $2.3 * 10^8$ m/s.**

Bandwidth link =10Gbps =10^{10}bps
Time =1/10^{10}bps = 0.1nsec
Speed of propagation is $2.3 * 10^8$ m/s

Distance = Speed x Time
= $2.3 * 10^8$ m/s. x 0.1nsec
= 23mm
= 0.023m

9. **(16 pts) Suppose two hosts, A and B, are separated by 20,000 kilometers and they are connected by a direct link of R=1Gbps. Suppose the propagation speed over the link is 2.5 x 10^8 meters/sec.**

   a. **Calculate the bandwidth delay product (BDP) of the link.**

   Propagation Delay = Distance x Speed
   =20,000 x 1000m x 2.5 x 10^8 meters/sec.
   =80msec

   Bandwidth Delay Product (BDP)= Delay x Bandwidth
   =80msec x 1Gbps
   =80Mb
   =80 x 10^6 bits

   b. **Consider sending a file of 800,000 bits from Host A to Host B as one large message. What is the maximum number of bits that will be in the link at any given time?**

   It should be equal to the size of the sending file **800,000 bits**

   c. **What is the width (in meters) of a bit in the link?**

   Bandwidth =1Gbps

Time $= 1/(1\text{Gbps})$

$= 1\text{nsec}$

Width $=$ speed x time

$= 2.5 \times 10^8$ meters/sec x 1nsec

Width = 25cm or 0.25m

d. **Suppose now the file is broken up into 20 packets with each packet containing 40,000 bits. Suppose that each packet is acknowledged by the receiver and the transmission time of an acknowledgement packet is negligible. Finally, assume that the sender cannot send a packet until the preceding one is acknowledged. How long does it take to send the file?**

Total time = No. of Packets(Transmission delay +2(Propagation delay))

Transmission Time =BDP/ Bandwidth
Propagation Delay = Distance x Speed
=No. of Packets(BDP/ Bandwidth +2(Distance x Speed))
$=20((4000/10^9) + (2 \times 20000 \times 10^{8)}/(2.5 \times 10^8))$
=3.2008s

10. **(12 pts) Suppose there is a 10 Mbps microwave link between a geostationary satellite and its base station on Earth. Every minute the satellite takes a digital photo and sends it to the base station. Assume a propagation speed of 2.4×10^8 meters/sec. Geostationary satellite is 36,000 kilometers away from earth surface**

a. **What is the propagation delay of the link?**

Bandwidth= 10 Mbps
propagation speed of 2.4×10^8 meters/sec

Distance = 36,000 kilometers

Propagation Delay = Distance / propagation speed

=0.15s

b. **What is the bandwidth-delay product, R x (propagation delay)?**

bandwidth-delay product = Propagation Delay x Bandwidth

= 0.15 x 10 Mbps

=1.5Mb

=1.5 x 10^6 bits

c. **Let *x* denote the size of the photo. What is the minimum value of *x* for the microwave link to be continuously transmitting?**

For a continuous transmission each digital photo needs to be sent at a frequency of one per minute as per question

Frequency =60 seconds

x =Bandwidth x Time

=10 x 10^7 x 60

=60 x 10^8 bits

The minimum value of *x* for the microwave link to be continuously transmitting =60 x 10^8 bits