Note: Provide Detailed solutions and not just final answers. Final Answers only will get a mark of zero.

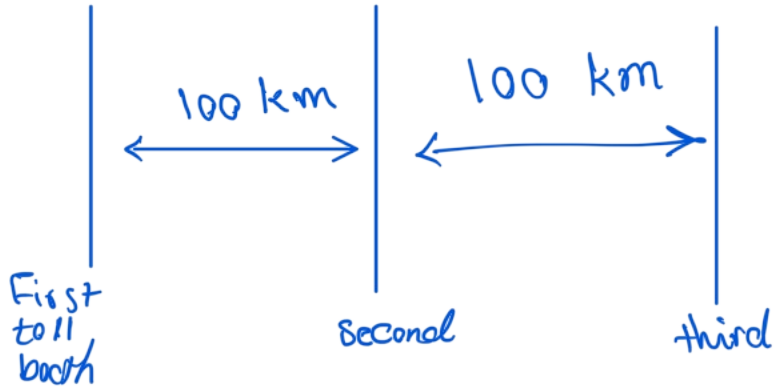
Problem-1:

Review the car-caravan analogy in Section 1.4. Assume a propagation speed of 100 km/hour.

a. Suppose the caravan travels 150 km, beginning in front of one tollbooth, passing through a second tollbooth, and finishing just after a third tollbooth. What is the end-to-end delay?

b. Repeat (a), now assuming that there are eight cars in the caravan instead of ten.

a) propagation delay => time required from first router – second router.



A) propagation speed = 100 km/hr => 100/60 km/min

first leg 100 km/hr => 100/(10/6) = 60 min

Second leg 50 km/hr => 50/(10/6) = 30 min

min per car => 10 mins for 10 cars

two tollbooth => 2x10 = 20

Sum = end-end => 20 + 30 + 60 = 110 min

B) First leg => 60 {found previous item} delay

Second leg => 30

one car (1min) => 8 cars 8 mins

two tollbooth => 2x8 = 16

Sum = 30 + 60 + 16 = 106 mins delay

Note: Provide Detailed solutions and not just final answers. Final Answers only will get a mark of zero.

Problem-2:

Suppose users share a 3 Mbps link. Also suppose each user requires 150 kbps when transmitting, but each user transmits only 10 percent of the time. (See the discussion of packet switching versus circuit switching in Section 1.3.)

a. When circuit switching is used, how many users can be supported?

b. For the remainder of this problem, suppose packet switching is used. Find the probability that a given user is transmitting.

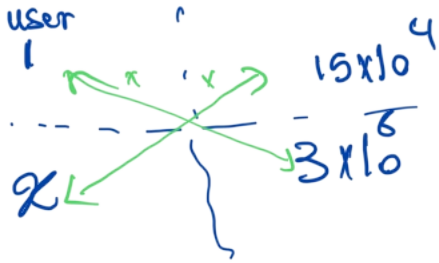
c. Suppose there are 120 users. Find the probability that at any given time, exactly n users are transmitting simultaneously. (*Hint*: Use the binomial distribution.)

d. Find the probability that there are 21 or more users transmitting simultaneously.

a. The link is devided among users equally.

$150\,kbps \Rightarrow 15\times10^{4}\,bps$

$3\,MBps \Rightarrow 3\times10^{6}\,bps$



$\Rightarrow 3\times10^{6} = 15x\times10^{4}$

$x = \frac{3}{15}\times100$

$x = \frac{300}{15}$

$x = 20$ users

b) as the textbook describes, the probability that a user is active is 10%, other words $\frac{10}{100} = 0.1$

C. Binomial Formula

$$\binom{x}{n} p^n (1-p)^{x-n} \quad x=120 \Longrightarrow \binom{120}{n} p^n (1-p)^{120-n}$$

$$\binom{120}{n} (0.1)^n (1-(0.1))^{120-n}$$

$$\binom{120}{n} (0.1)^n (0.9)^{120-n}$$

d. $1 - \sum_{n=0}^{20} \binom{120}{n} p^n (1-p)^{120-n}$

when it says 21 users or $\Rightarrow P\sum_{n=1}^{120} x_i \leq 21 = P(x \leq 2.74)$

$= 0.997$

x is a normal and standard $\Rightarrow$ P(21 or more users)

≈ 0.003

Note: Provide Detailed solutions and not just final answers. Final Answers only will get a mark of zero.

Problem-3:

Consider the network illustrated in Figure 1.16. Assume the two hosts on the left of the figure start transmitting packets of 1500 bytes at the same time towards Router B. Suppose the link rates between the hosts and Router A is 4-Mbps. One link has a 6-ms propagation delay and the other has a 2-ms propagation delay. Will queuing delay occur at Router A?

$1500 \times 8 = 12000$

$$\frac{12000}{4 \times 10^6} = \frac{12 \times 10^3}{4 \times 10^6} = 3 \times 10^{-3} \Rightarrow 3ms$$

$3\,ms + 2ms = 5\,ms$

$\Rightarrow 6 > 5 \Rightarrow$ no it will not occure at A.

Note: Provide Detailed solutions and not just final answers. Final Answers only will get a mark of zero.

Problem-4:

Suppose two hosts, A and 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 $2.5 \cdot 10^8$ meters/sec.

a. Calculate the bandwidth-delay product, $R \cdot d_{prop}$.

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?

c. Provide an interpretation of the bandwidth-delay product.

d. What is the width (in meters) of a bit in the link? Is it longer than a football field?

e. Derive a general expression for the width of a bit in terms of the propagation speed s, the transmission rate R, and the length of the link m.

a. $R = 2$ Mbps $\Rightarrow 2 \times 10^6$ bps

2.5×10^8 1 s $\Longrightarrow$ $2.5 \times 10^7 x = 2 \times 10^7$

2×10^7 x $x = \frac{2}{25} = 8 \times 10^{-2}$

$\Rightarrow R \cdot d_{pro} = 8 \times 10^{-2} \times 2 \times 10^6 = 16 \times 10^4$ bits

b. The max bit is exactly equal to the bandwidth
So in this case the answer is 16×10^4 or 160000 Bits

C. BDP is a measure the performance quality of a network. Bandwith is the data transmission of data. and Dely is the time takes that data gets transferred from sender to the reciever.

D. Bit length $= \frac{\text{Speed of signal}}{\text{Bandwidth}} \Longrightarrow \frac{2 \times 10^{7}}{1.6 \times 10^{5}} = 125 \text{ m/s}$

So Football Field is about 110 and what we found is 125 $\Longrightarrow$ it is larger than a football field.

E. length $= m$, bandwith-delay $= \frac{Rm}{S}$

$$\frac{m}{R(m/s)} = \frac{\frac{m}{1}}{\frac{Rm}{S}} = \frac{S \cdot m}{R \cdot m} = \frac{S}{R}$$

Note: Provide Detailed solutions and not just final answers. Final Answers only will get a mark of zero.

Problem-5:

Consider sending a large file of F bits from Host A to Host B. There are three links (and two switches) between A and B, and the links are uncongested (that is, no queuing delays). Host A segments the file into segments of S bits each and adds 80 bits of header to each segment, forming packets of $L = 80 + S$ bits. Each link has a transmission rate of R bps. Find the value of S that minimizes the delay of moving the file from Host A to Host B. Disregard propagation delay.

$S = 80$ bits

we know the first router gets $\frac{S+80}{R} \times \frac{F}{S}$ (secs)

First, $(F/S)-2$ packets are in the begging.

For each transision takes $\frac{S+80}{R}$ (sec) delay

So the whole file delay should $\left(\frac{S+80}{R}\right)\left(\frac{F}{S}+2\right)$

we need to find the derivate of the equation and solve it for 0.

$$\frac{d}{dS}\left(\frac{S+80}{R}\right)\left(\frac{F}{S}+2\right)=0$$

we use online symbolab software to solve the equation for us $\Rightarrow$ $S = \sqrt{40F}$