Assignment #1

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Computer Networks

K191048

Roll No: K191048 – Amman Soomro
Section: BSE – 5A

QUESTION NO 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. If the switch uses store-and-forward packet switching, what is the total end-to-end delay to send a packet of length L? (Ignore queuing, propagation delay, and processing delay.

Data:

L = Length of Packet

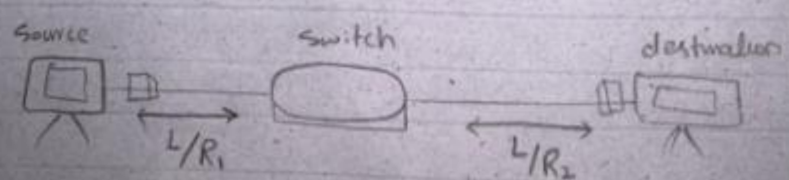
R_1 = Transmission rate b/w source host and switch

R_2 = Transmission rate b/w switch and recieving host.

- Time taken by the host to reach the switch from source host = L/R_1

- Time taken by the Packet to reach the destination host from switch = L/R_1

∴ Total end-to-end delay = $L/R_1 + L/R_2$.



QUESTION NO 2

Which layers in the Internet protocol stack does a router process and what kind of message use in this layer? Which layers does a link-layer switch process? Which layers does a host process? Explain with the help of figure.

- Since router is a physical device it acts as an medium between the hosts and network, so it process physical layer.
  Some router also process data link layer and network link layer.
  Some act as firewalls so they also process transport layer.

- The link layer switch processes the physical layer and the data-link layer.

- The host process all 5 layer of the internet protocol stack.

QUESTION NO 3

Why layering is important in internet protocol stack? Explain your answer in detail with the help of figure or analogy. Name the protocols use in each inter protocol layer?

Question no 3:

Because it is easy to monitor data and look for errors in layers rather than a single bulk. If there is a problem in any layer only that layer needs to be checked.

Analogy:

Consider booking a ticket and a plane flight

First you book your ticket, then your baggage are checked, then you are loaded into the flight, then the plane select the best route and propogates towards its destination.

QUESTION NO 4

Consider the circuit-switched network in Figure 1.13. Recall that there are four circuits on each link. Label the four switches A, B, C, and D, going in the clockwise direction.

a. What is the maximum number of simultaneous connections that can be in progress at any one time in this network?

b. Suppose that all connections are between switches A and C. What is the maximum number of simultaneous connections that can be in progress?

c. Suppose we want to make four connections between switches A and C, and another four connections between switches B and D. Can we route these calls through the four links to accommodate all eight connections?

a) Since there are 4 switches and each consisting of 4 links hence each switch can have 4 connection. So the maximum no of connections that can be in progress simultaneously are: 16

b) 4 Connections from switch A.
4 Connections from switch C
Maximum no of connections: 8

c) Yes it is possible.
For connection between A and C we can route 4 connections through B and D. 2 connections each and similarly for connection between B and D we can route 4 connections through A and C. 2 connections each.

QUESTION NO 5

This elementary problem begins to explore propagation delay and transmission delay, two central concepts in data networking. 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.

a. Express the propagation delay, dprop, in terms of m and s. b. Determine the transmission time of the packet, dtrans, in terms of L and R.

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

d. Suppose Host A begins to transmit the packet at time t = 0. At time t = dtrans, where is the last bit of the packet?

e. Suppose dprop is greater than dtrans. At time t = dtrans, where is the first bit of the packet?

f. Suppose dprop is less than dtrans. At time t = dtrans, where is the first bit of the packet? Suppose s = 2.5 *108, L = 1500 bytes, and R = 10 Mbps. Find the distance m so that dprop equals dtrans.

a) Propogation delay in terms of m and s will be m/s.

b) Transmission time of the packet in terms of L and R will be L/R.

c) $d_{end\text{-}to\text{-}end} = (d_{proc} + d_{trans} + d_{queue} + d_{prop})$

but ignoring processing and queing delay:

- $d_{end\text{-}to\text{-}end} = (d_{trans} + d_{prop})$
- $d_{end\text{-}to\text{-}end} = (m/s + L/R)$ seconds.

d) The last bit will be leaving host A

e) If propogation delay is greater than the transmission delay then the first packet bit is still propogating and has not reached it's destination.

f) If propogation delay is less than the transmission delay then the first bit has reached it's destination

g) $\frac{m}{s} = \frac{L}{R} \Rightarrow m = \frac{Ls}{R}$

$\Rightarrow \frac{(12000)(2.5 \times 10^8)}{(10 \times 10^6)} \Rightarrow 300000$ km

QUESTION NO 6

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 * 108 meters/sec.

a. What is the propagation delay of the link?

b. What is the bandwidth-delay product, R.dprop?

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

- Distance of satellite from Earth surface: 36,000km $\Rightarrow d = 36 \times 10^7 m$
- Propogation speed $(s) = 2.4 \times 10^8$ m/s
- Transmission rate $(R) =$ 10Mbps $\rightarrow 10 \times 10^6 \rightarrow 10^7$

a)

- $d_{prop} = d/s \Rightarrow \dfrac{3.6 \times 10^7}{2.4 \times 10^8} \rightarrow 0.15$ sec
- Propogation delay of link : 0.15 secs.

b) $R = 10^7$

dprop $\Rightarrow$ 0.15

R.dprop = 1,500,000 bits Ans.

- Bandwidth delay is 1,500,000 bits.

c) Since satellite transmits a photo every 60 seconds and transmission rate is 10^7.

value of $x(min) = 60 \times 10^7 \rightarrow$ 600,000,000 bits.

- So the minimum value of x for continuous transmission should be 600,000,000 bits.

QUESTION NO 7

Suppose two hosts, A and B, are separated by 20,000 kilometers and are connected by a direct link of R = 5 Mbps. Suppose the propagation speed over the link is 2.5 *108 meters/sec.

a. Calculate the bandwidth-delay product, R * dprop.

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.

- distance (d) = 20.000km → 2×10^7 m
  Transmission Rate (R) = 5mbps → 5×10^6 bps
  Propagation speed (s) = 2.5×10^8 m/s

a) dprop = d/s → $\frac{2\times10^7}{2.5\times10^8}$ → 0.08

→ R*prop → $5\times10^6\times0.08$ → 400000

- Bandwidth delay is 400,000 bits.

b) File size → 800.000 bits.

- Band width-delay = 400.000
- Hence maximum no of bits at any given time will be 400.000 bits.

c) The product of bandwidth delay tells us the maximum number of bits for transmission.

d) Length/width of a bit $\Rightarrow \dfrac{S}{R} \rightarrow \dfrac{2.5 \times 10^{8}}{5 \times 10^{6}} \Rightarrow 50\,m/bit$

~~the, it is~~

Football field = 91 m

No, it is no longer than a football field.

e) $\dfrac{m}{R} * d_{prop} = m/R * m/s$

$\Rightarrow \dfrac{\cancel{m}}{R} \times \dfrac{s}{\cancel{m}}$

$\Rightarrow \dfrac{s}{R}$

QUESTION NO 8

In this problem, we consider sending real-time voice from Host A to Host B over a packet-switched network (VoIP). Host A convert's analog voice to a digital 64 kbps bit stream on the fly. Host A then groups the bits into 56-byte packets. There is one link between Hosts A and B; its transmission rate is 10 Mbps and its propagation delay is 10 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 to an analog signal. How much time elapses from the time a bit is created (from the original analog signal).

R = 10×10^6 bps
Convertion to analog: 64×10^3 bits
dprop: 10×10^{-3} sec
Packets: 448 bits

Total transmission time, dprop: $\frac{448}{10 \times 10^3} \Rightarrow 0.007$ sec
dtrans: $\frac{448}{10 \times 10^6} = 4.48 \times 10^{-5}$ sec.

dend to end = $0.007 + 4.48 \times 10^{-5} + 10 \times 10^{-3}$
$\Rightarrow 0.0172$ sec

QUESTION NO 9

Review the car-caravan analogy in Section 1.4. Suppose the caravan has 10 cars, and that the tollbooth services (that is, transmits) a car at a rate of one car per 2 seconds. Assume a propagation speed of 100 km/hour.

a. Suppose the caravan travels 175 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 Speed = 100Km/h
Caravan Speed = 175km/h
Transmission rate = 2 seconds

$\rightarrow \frac{175 \text{ km/h}}{100 \text{ km/h}} \rightarrow 1.75\text{hr} \rightarrow$ 1hour 45min.

- Overall service time for 10 cars = $10 \times 2 \times 3 \Rightarrow 60$sec
- End to end delay = 1hour 45mins +1min
  = 1hour 46mins.

b) Overall service time for 8 cars = $8 \times 2 \times 3 = 48$secs

- 48sec = 0.76 min
- End to end delay → 60mins +45mins +0.76min
  → 105.76 mins OR
  → 1hour 45mins 48seconds.

QUESTION NO 10

Consider a packet of length L that begins at end system A and travels over three links to a destination end system. These three links are connected by two packet switches. Let di, si, and Ri denote the length, propagation speed, and the transmission rate of link i, for i = 1, 2, 3. The packet switch delays each packet by dproc. Assuming no queuing delays, in terms of di, si, Ri, (i = 1, 2, 3), and L, what is the total end-to-end delay for the packet? Suppose now the packet is 1,500 bytes, the propagation speed on all three links is 2.5 # 108m/s, the transmission rates of all three links are 2.5 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?

$L = 1500$ ~~bits~~ bytes → 12000 bits

$d_{proc} = 3$ msec → 0.003

$R = 2.5 \times 10^6$

$d_1 = 5000$ km → 5000×10^3

$d_2 = 4000$ km → 4000×10^3

$d_3 = 1000$ km → 1000×10^3

$S = 2.5 \times 10^8$

- $delay_{end\text{-}to\text{-}end} = L/R_1 + L/R_2 + L/R_3 + d_1/s_1 + d_2/s_2 + d_3/s_3 + d_{proc} + d_{proc}$

→ $0.004 + 0.004 + 0.004 + 0.02 + 0.016 + 0.004 + 0.003 + 0.003$

→ 0.058 sec.

- So end to end delay is 0.058 seconds.

QUESTION NO 11

In the above problem, suppose R1 = R2 = R3 = R and dproc = 0. Further suppose that the packet switch does not store-and-forward packets but instead immediately transmits each bit it receives before waiting for the entire packet to arrive. What is the end-to-end delay?

Question no: 11.

$R_1 = R_2 = R_3 = R \rightarrow 2.5 \times 10^6$

$L = 1500$ bytes $= 12000$ bits

$S = 2.5 \times 10^8$

$d_{proc} = 0$

- $L/R = \frac{12000}{2.5 \times 10^6} \Rightarrow 0.004$

- $d_1/s_1 = 0.02$
- $d_2/s_2 = 0.016$
- $d_3/s_3 = 0.004$

- $d_{end\text{-}to\text{-}end} = 0.004 + 0.02 + 0.016 + 0.04$

  $\rightarrow 0.08$ seconds