Chapter-1

R11

At time t_0, the sending host begin to transmit.
At time $t_1 = \frac{L}{R_1}$, the sending host completes transmission and the entire packet is received at the router (no propogation delay).
Because, the router has the entire packet at time t_1, it can begin to transmit the packet to the receiving host at time t_1.
At time $t_2 = t_1 + \frac{L}{R_2}$, the router completes transmission and the entire packet is received at the receiving host (no, propogation delay).

Thus, the end to end delay is $\frac{L}{R_1} + \frac{L}{R_2}$.

R13

(a)

As, each user requires half of the link bandwidth, ~~to~~ so 2 users can be supported.

(b)

Since, each user requires 1Mbps when transmitting, if two or fewer users transmit simultaneously, a maximum of 2Mbps will be required.

Since, the available bandwidth of the shared link is 2Mbps, there will be no queuing delay before the link.

Whereas, if three users transmit simultaneously, the bandwidth require will be 3Mbps which is more than the available bandwidth of the shared link. In this case, there will be queuing delay before the link.

R16

The delay components are:

- Processing delays
- Transmission delays
- Propogation delays
- Queuing delays.

Fixed delays:

(i) Processing delays
(ii) Transmission delays
(iii) Propogation delays.

Variable delays:

(i) Queuing delays.

R18

$$\text{Time taken} = \frac{2500 \times 1000}{2.5 \times 10^8}$$
$$= 0.01s$$
$$= 10ms$$

More generally, time taken is $= \frac{d}{s}$, where,

d = distance
s = propagation speed.

The delay does not depend on packet length and also does not depend on transmission rate.

R19

a) Given link rates:

$R1 = 500$ Kbps

$R2 = 2$ Mbps (2000kbps)

$R3 = 1$ Mbps (1000 kbps)

The throughput is the minimum of the link rates, which means the bottleneck link's rate will limit the file transfer speed.

$\therefore$ Throughput $= \text{Min}(R1, R2, R3)$

$= \text{Min}(500, 2000, 1000)$

$= 500$ kbps Ans

b) We know,

$$\text{Transfer time (in seconds)} = \frac{\text{File size (in bits)}}{\text{Throughput (in bps)}}$$

Given, File size $= 4$ million bytes

$= 4 \times 10^6$ byte

$= 4 \times 10^6 \times 8$ bits $= 32 \times 10^6$ bits

Throughput $= 500$ kbps [from a]

$= \cancel{5000} 500 \times 10^3$ bps

$$\therefore \text{Transfer time} = \frac{32 \times 10^6}{5 \times 10^5} \text{ s}$$

$= 64$ seconds

$\therefore$ So, it will take approx. 64 seconds. (Ans)

c) Now, R2 reduces to 100kbps

So, $R1 = 500$ kbps

$R2 = 100$ kbps

$R3 = 1$ Mbps (1000 kbps)

$\therefore$ Throughput = Min (R1, R2, R3)

= Min (500, 100, 1000)

= 100 kbps

(Ans)

Now,

$$\text{New Transfer time} = \frac{4 \times 10^6 \times 8}{100 \times 10^3}$$

$$= \frac{32 \times 10^6}{1 \times 10^5}$$

= 320 seconds.

(Ans)

P3

(A)

A circuit-switched network would be well suited to the application.

Because, the application involves long sessions with predictable smooth bandwidth ~~can be~~ requirements. Since the transmission rate is known and not bursty, bandwidth can be reserved for each application session without significant waste.

In addition, the overhead costs of setting up and tearing down connections are amortized over the lengthy duration of a typical application session.

(B)

In the worst case, all the applications simultaneously transmit over one or more network links. However, since each link has sufficient bandwidth to handle the sum of all of the applications' data rates, no congestion (very little queuing) will occur. Given such generous link capacities, the network doesn't need congestion control mechanisms.

P(5)

(a)

The caravan travels 150 km.
Assume a propogation speed of 100km/hour

$$\text{Delay time} = \frac{\text{total distance}}{\text{Propogation speed}}$$
$$= \frac{150}{100}$$
$$= 1.5 \text{ hours}$$

There are ten cars and it takes 120 seconds or 2 minutes, for the first ~~toot~~ tollbooth to service the 10 cars.

∴ Time for taken by 3 tollbooths to reach 10 cars = $2 * 3 = 6$ mins

∴ So, end-to-end delay = 1.5 hours + 6 minutes
= 1 hour 36 minutes
= 96 minutes.

Ans

(b)

Assuming that there are 8 cars in caravan now.

∴ Time for taken 3 tollbooths to reach 8 cars = $3 \times (0.2 \times 8) = 4.8$ minutes

∴ So. end-to-end delay = 90 minutes + 4.8 minutes
= 94.8 minutes (Ans)

P6

(a)

Propogation delay $d_{prop} = \frac{m}{s}$ seconds

(b)

Transmission time of the packet $d_{trans} = \frac{L}{R}$ seconds

(c)

Ignoring processing and queuing delays,

$\therefore$ End-to-end delay $= \frac{m}{s} + \frac{L}{R}$ seconds
($d_{end\text{-}to\text{-}end}$)

(d)

At time $t = d_{trans}$, The bit is just leaving Host A.

(e)

The first bit is in the link and has not reached Host B. Because, if $d_{prop} > d_{trans}$, the propgation delay is longer than the transmission time,

(f)

If $d_{prop} < d_{trans}$, the propogation delay is shorter than the transmission time.

$\therefore$ The first bit has reached Host B.

(g)

Hence, $\frac{m}{s} = \frac{L}{R}$

$\Rightarrow m = \frac{L}{R} \times s$

$\Rightarrow m = \frac{120}{56 \times 10^3} \times (2.5 \times 10^8)$

$\therefore m = 536 km$

Here,
$s = 2.5 \times 10^8$ m/s
$R = 56$ kbps
$= 56 \times 10^3$ bps
$L = 120$ bits

P7

Given,

Transmission rate (R) = 2 Mbps = 2×10^6 bps

Propogation delay d_{prop} = 10 ms = 0.01 s

Packet size (L) = 56 bytes = 56 × 8 = 448 bits

Conversion rate at Host A = 64kbps = 64×10^3 bps

$$d_{trans} = \frac{L}{R} = \frac{448}{2\times10^6} = 0.000224 \text{ s}$$

decoding time for Host B to convert the received packets bits back into an analog signal.

$$d_{decode} = \frac{L}{64\times10^3} = \frac{448}{64\times10^3} = 0.007 \text{ s}$$

Elapsed time from creation to decoding:

$$\therefore \text{Elapsed time} = d_{trans} + d_{prop} + d_{decode}$$

$$= 0.000224 + 0.01 + 0.007$$

$$= 0.017224 \text{ s}$$

(Ans)

P12

Given,

Packet length $L = 1500$ bytes

Transmission rate $R = 2\,Mbps = 2 \times 10^6$ bps

Currently transmitted packet $= x$ bits $= \frac{1500}{2} = 750$ bits

waiting queue $= n$ packets $= 4$

We know,

$$\text{Queuing delay} = \frac{[nL + (L-x)]}{R}$$

Now,

$[nL + (L-x)] = (4 \times 1500) + (1500 - 750)$

$= 6000 + 750$

$= 6750$ bytes

Packets are transmitted at 2 Mbps.

$= 6750 * 2 * 4$

$= 54000$

$$\therefore \text{Queuing delay} = \frac{54000}{2 \times 10^6} = 0.027 \text{ sec}$$

Ans