Tutorials (Practice Problems)

Problem-01:

If the bandwidth of the line is 1.5 Mbps, RTT is 45 msec and packet size is 1 KB (in binary unit), then find the link utilization in stop and wait.

Solution:

Given-
Bandwidth = 1.5 Mbps
RTT = 45 msec
Packet size = 1 KB
Calculating Transmission Delay-
Transmission delay (Tt)
= Packet size / Bandwidth
= 1 KB / 1.5 Mbps
= (2^10 x 8 bits) / (1.5 x 10^6 bits per sec)
= 5.461 msec
Calculating Propagation Delay-
Propagation delay (Tp)
= Round Trip Time / 2
= 45 msec / 2
= 22.5 msec
Calculating Value Of 'a'-
a = Tp / Tt
a = 22.5 msec / 5.461 msec
a = 4.12
Calculating Link Utilization-
Link Utilization or Efficiency (η) %
= 1 / 1+2a
= 1 / (1 + 2 x 4.12)
= 1 / 9.24
= 0.108
= 10.8 %

Problem-02:
A channel has a bit rate of 4 Kbps and one-way propagation delay of 20 msec. The channel uses stop and wait protocol. The transmission time of the acknowledgement frame is negligible. Find the minimum frame size to get a channel efficiency of at least 50%.

Solution-

Given-

Bandwidth = 4 Kbps

Propagation delay (Tp) = 20 msec.

Efficiency >= 50%

Let the required frame size = L bits.

Calculating Transmission Delay-

Transmission delay (Tt)

= Packet size / Bandwidth

= L bits / 4 Kbps

Calculating Value of ‘a’-

a = Tp / Tt

a = 20 msec / (L bits / 4 Kbps)

a = (20 msec x 4 Kbps) / L bits

Condition For Efficiency To Be At least 50%-

or efficiency to be at least 50%, we must have-

1 / 1+2a >= 1/2

a <= 1/2

Substituting the value of ‘a’, we get-

(20 msec x 4 Kbps) / L bits <= 1/2

L bits >= (20 msec x 4 Kbps) x 2

L bits >= (20 x 10^-3 sec x 4 x 10^3 bits per sec) x 2

L bits >= 20 x 4 bits x 2

L >= 160

From here, frame size must be at least 160 bits.

Problem-03:

What is the throughput in MBps achievable in stop and wait protocol by a maximum packet size of 1000 bytes and network span of 10 km. Assume the speed of light in cable is 70% of the speed of light in vacuum (3 x 10^8 m/sec).

Solution-

$$\text{Throughput} = \text{Efficiency} \times \text{Bandwidth}$$

$$\text{Throughput} = \frac{T_t}{T_t + 2 \times T_p} \times \text{Bandwidth}$$

$$\text{Throughput} = \frac{L / B}{T_t + 2 \times d / v} \times B$$

$$\text{Throughput} = \frac{L}{2 \times d / v}$$

-In the given question, we are not provided with the network's bandwidth.
-So, in the above formula of throughput, we have ignored the term Tt from the denominator.
-Although it is incorrect, but we still ignore it for solving the question.
Now, Given-
L = 1000 bytes
d = 10 km = 10^4 m
v = 70% of 3 x 10^8 m/sec = 2.1 x 10^8 m/sec
Substituting the values in the above relation, we get-
Throughput
= 1000 bytes / [2 x 10^4 m / (2.1 x 10^8 m/sec)]
= 1.05 x 10^7 bytes per sec
= 10.5 MBps

Problem-04:

If the packet size is 1 KB (binary unit) and propagation time is 15 msec, the channel capacity is 10^9 b/sec, find the transmission time and utilization of sender in stop and wait protocol.

Solution-

Given-
Packet size = 1 KB
Propagation time (Tp) = 15 msec
Channel capacity = Bandwidth (here) = 10^9 b/sec

NOTE-
-Generally, channel capacity is the total number of bits which a channel can hold. So, its unit is bits.
-But here, channel capacity is actually given as bandwidth because its unit is b/sec.

Calculating Transmission Delay-
Transmission delay (Tt)
= Packet size / Bandwidth
= 1 KB / 10^9 bits per sec
= 2^10 bits / 10^9 bits per sec
= 1.024 μsec.

Calculating Value of 'a'-
a = Tp / Tt
a = 15 msec / 1.024 μsec
a = 15000 μsec / 1.024 μsec
a = 14648.43

Calculating Sender Utilization-
Sender Utilization or Efficiency (η)

= 1 / 1+2a
= 1 / (1 + 2 x 14648.43)
= 1 / 29297.86
= 0.000003413
= 0.0003413 %

Problem-05:

Consider a MAN with average source and destination 20 Km apart and one-way delay of 100 µsec. At what data rate does the round trip delay equal the transmission delay for a 1 KB packet?

Solution-

Given-

Distance = 20 Km
Propagation delay (Tp) = 100 µsec
Packet size = 1 KB
We need to have-
Round Trip Time = Transmission delay   (Given)
2 x Propagation delay = Transmission delay
Substituting the values in the above relation, we get-
2 x 100 µsec = 1 KB / Bandwidth
Bandwidth = 1 KB / 200 µsec
Bandwidth = (2^10 x 10^6 / 200) bytes per sec
Bandwidth = 5.12 MBps or 40.96 Mbps

Problem-06:

Consider two hosts X and Y connected by a single direct link of rate 10^6 bits/sec. The distance between the two hosts is 10,000 km and the propagation speed along the link is 2 x 10^8 m/sec. Host X sends a file of 50,000 bytes as one large message to host Y continuously. Let the transmission and propagation delays be p milliseconds and q milliseconds respectively. Find the value of p and q.

Solution-

Given-

Bandwidth = 10^6 bits/sec
Distance = 10,000 km
Propagation speed = 2 x 10^8 m/sec
Packet size = 50,000 bytes
Calculating Transmission Delay-
Transmission delay (Tt)
= Packet size / Bandwidth
= 50000 bytes / 10^6 bits per sec

= (5 x 10^4 x 8 bits) / 10^6 bits per sec
= (4 x 10^5 bits) / 10^6 bits per sec
= 0.4 sec
= 400 msec.

Calculating Propagation Delay-

Propagation delay (Tp)
= Distance / Propagation speed
= 10000 km / (2 x 10^8 m/sec)
= 10^7 m / (2 x 10^8 m/sec)
= 50 msec

Problem-07:

The values of parameters for the stop and wait ARQ protocol are as given below-
Bit rate of the transmission channel = 1 Mbps
Propagation delay from sender to receiver = 0.75 ms
Time to process a frame = 0.25 ms
Number of bytes of the information frame = 1980
Number of bytes in the acknowledge frame = 20
Number of overhead bytes in the information frame = 20
Assume that there are no transmission errors. Find the transmission efficiency of data of the stop and wait ARQ protocol for the above parameters. (correct to 2 decimal places)

Solution-

Given-

Bandwidth = 1 Mbps
Propagation delay (Tp) = 0.75 ms
Processing time (Tprocess) = 0.25 ms
Information frame size = 1980 bytes
Acknowledgement frame size = 20 bytes
Overhead in data frame = 20 bytes

Calculating Useful Time-

Useful data sent
= Transmission delay of useful data bytes sent
= Useful data bytes sent / Bandwidth
= (1980 bytes – 20 bytes) / 1 Mbps
= 1960 bytes / 1 Mbps
= (1960 x 8 bits) / (10^6 bits per sec)
= 15680 µsec
= 15.680 msec

Calculating Total Time-

Total time
= Transmission delay of data frame + Propagation delay of data frame + Processing delay of data frame + Transmission delay of acknowledgement + Propagation delay of acknowledgement
= (1980 bytes / 1 Mbps) + 0.75 msec + 0.25 msec + (20 bytes / 1 Mbps) + 0.75 msec
= 15.840 msec + 0.75 msec + 0.25 msec + 0.160 msec + 0.75 msec
= 17.75 msec.

Calculating Data Transmission Efficiency-

Efficiency (η)
= Useful time / Total time
= 15.680 msec / 17.75 msec
= 0.8833
= 88.33%.

Problem-08:

A sender uses the stop and wait ARQ protocol for reliable transmission of frames. Frames are of size 1000 bytes and the transmission rate at the sender is 80 Kbps. Size of an acknowledgement is 100 bytes and the transmission rate at the receiver is 8 Kbps. The one-way propagation delay is 100 msec. Assuming no frame is lost, find the sender throughput in bytes/sec.

Solution-

Given-

Frame size = 1000 bytes
Sender bandwidth = 80 Kbps
Acknowledgement size = 100 bytes
Receiver bandwidth = 8 Kbps
Propagation delay (Tp) = 100 msec.

Calculating Transmission Delay Of Data Frame-

Transmission delay (Tt)
= Frame size / Sender bandwidth
= 1000 bytes / 80 Kbps
= (1000 x 8 bits) / (80 x 10^3 bits per sec)
= 0.1 sec
= 100 msec.

Calculating Transmission Delay of Acknowledgement-

Transmission delay (Tt)
= Acknowledgement size / Receiver bandwidth
= 100 bytes / 8 Kbps
= (100 x 8 bits) / (8 x 10^3 bits per sec)

= 100 msec.

Calculating Useful Time-

Useful Time

= Transmission delay of data frame

= 100 msec.

Calculating Total Time-

Total Time

= Transmission delay of data frame + Propagation delay of data frame + Transmission delay of acknowledgement + Propagation delay of acknowledgement

= 100 msec + 100 msec + 100 msec + 100 msec

= 400 msec.

Calculating Efficiency-

Efficiency (η) %

= Transmission time / Total time

= 100 msec / 400 msec

= 1 / 4

= 25%

Calculating Sender Throughput-

Sender throughput

= Efficiency (η) x Sender bandwidth

= 0.25 x 80 Kbps

= 20 Kbps

= (20 x 1000 / 8) bytes per sec

= 2500 bytes/sec.