PRACTICE PROBLEMS BASED ON STOP AND WAIT PROTOCOL-

Problem-01:

If the bandwidth of the line is 1.5 Mbps, RTT is 45 msec and packet size is 1 KB, 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 (T_t)

= 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 (T_p)

= Round Trip Time / 2

= 45 msec / 2

= 22.5 msec

Calculating Value Of ‘a’-

$a = T_p / T_t$

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. To get a channel efficiency of at least 50%, the minimum frame size should be-

1. 80 bytes
2. 80 bits
3. 160 bytes
4. 160 bits

Solution-

Given-

- Bandwidth = 4 Kbps
- Propagation delay (T_p) = 20 msec
- Efficiency >= 50%

Let the required frame size = L bits.

Calculating Transmission Delay-

Transmission delay (T_t)

= Packet size / Bandwidth

= L bits / 4 Kbps

Calculating Value Of ‘a’-

a = T_p / T_t

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

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

Condition For Efficiency To Be At least 50%-

For 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.

Thus, Correct Option is (D).

Problem-03:

What is the throughput 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 vaccum.

Solution-

We have-

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

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

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

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

- 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 T_t 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 and propagation time is 15 msec, the channel capacity is 10^9 b/sec, then find the transmission time and utilization of sender in stop and wait protocol.

Solution-

Given-

- Packet size = 1 KB
- Propagation time (T_p) = 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 (T_t)

= 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'-

$a = T_p / T_t$

a = 15 msec / 1.024 μsec

a = 15000 μsec / 1.024 μsec

a = 14648.46

Calculating Sender Utilization-

Sender Utilization or Efficiency (η)

= 1 / 1+2a

= 1 / (1 + 2 x 1468.46)

= 1 / 29297.92

= 0.0000341

= 0.00341 %

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 equals the transmission delay for a 1 KB packet?

Solution-

Given-

- Distance = 20 Km
- Propagation delay (T_p) = 100 μsec
- Packet size = 1 KB

We need to have-

Round Trip Time = Transmission delay

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.

Then the value of p and q are-

1. p = 50 and q = 100
2. p = 50 and q = 400
3. p = 100 and q = 50
4. p = 400 and q = 50

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 (T_t)

= 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 (T_p)

= Distance / Propagation speed

= 10000 km / (2 x 10^8 m/sec)

= 10^7 m / (2 x 10^8 m/sec)

= 50 msec

Thus, Option (D) is correct.

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 in 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. Then the transmission efficiency (in %) of the stop and wait ARQ protocol for the above parameters is ___________ . (correct to 2 decimal places)

Solution-

Given-

- Bandwidth = 1 Mbps
- Propagation delay (T_p) = 0.75 ms

- Processing time ($T_{process}$) = 0.25 ms
- Data 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 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, the sender throughput is __________ bytes/sec.

Solution-

Given-

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

Calculating Transmission Delay Of Data Frame-

Transmission delay (T_t)

= 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 (T_t)

= 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)

= Useful 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

Problem-09:

Using stop and wait protocol, sender wants to transmit 10 data packets to the receiver. Out of these 10 data packets, every 4th data packet is lost. How many packets sender will have to send in total?

Solution-

Draw a time line diagram and analyze.

The packets will be sent as-

1, 2, 3, **4**, 4, 5, 6, **7**, 7, 8, 9, **10**, 10

The lost packets are- 4, 7 and 10.

Thus, sender will have to send 13 data packets in total.

PRACTICE PROBLEMS BASED ON SLIDING WINDOW PROTOCOL-

Problem-01:

A 3000 km long trunk operates at 1.536 Mbps and is used to transmit 64 byte frames and uses sliding window protocol. If the propagation speed is 6 μsec / km, how many bits should the sequence number field be?

Solution-

Given-

- Distance = 3000 km
- Bandwidth = 1.536 Mbps
- Packet size = 64 bytes
- Propagation speed = 6 μsec / km

Calculating Transmission Delay-

Transmission delay (T_t)

= Packet size / Bandwidth

= 64 bytes / 1.536 Mbps

= (64 x 8 bits) / (1.536 x 10^6 bits per sec)

= 333.33 μsec

Calculating Propagation Delay-

For 1 km, propagation delay = 6 μsec

For 3000 km, propagation delay = 3000 x 6 μsec = 18000 μsec

Calculating Value Of 'a'-

a = T_p / T_t

a = 18000 μsec / 333.33 μsec

a = 54

Calculating Bits Required in Sequence Number Field-

Bits required in sequence number field

= $\lceil \log_2(1+2a) \rceil$

$= \lceil \log_2(1 + 2 \times 54) \rceil$

$= \lceil \log_2(109) \rceil$

$= \lceil 6.76 \rceil$

= 7 bits

Thus,

- Minimum number of bits required in sequence number field = 7
- With 7 bits, number of sequence numbers possible = 128
- We use only (1+2a) = 109 sequence numbers and rest remains unused.

Problem-02:

Compute approximate optimal window size when packet size is 53 bytes, RTT is 60 msec and bottleneck bandwidth is 155 Mbps.

Solution-

Given-

- Packet size = 53 bytes
- RTT = 60 msec
- Bandwidth = 155 Mbps

Calculating Transmission Delay-

Transmission delay (T_t)

= Packet size / Bandwidth

= 53 bytes / 155 Mbps

= (53 x 8 bits) / (155 x 10^6 bits per sec)

= 2.735 μsec

Calculating Propagation Delay-

Propagation delay (T_p)

= Round Trip Time / 2

= 60 msec / 2

= 30 msec

Calculating Value of 'a'-

a = T_p / T_t

a = 30 msec / 2.735 μsec

a = 10968.921

Calculating Optimal Window Size-

Optimal window size

= 1 + 2a

= 1 + 2 x 10968.921

= 21938.84

Thus, approximate optimal window size = 21938 frames.

Problem-03:

A sliding window protocol is designed for a 1 Mbps point to point link to the moon which has a one way latency (delay) of 1.25 sec. Assuming that each frame carries 1 KB of data, what is the minimum number of bits needed for the sequence number?

Solution-

Given-

- Bandwidth = 1 Mbps
- Propagation delay (T_p) = 1.25 sec
- Packet size = 1 KB

Calculating Transmission Delay-

Transmission delay (T_t)

= Packet size / Bandwidth

= 1 KB / 1 Mbps

= (2^{10} x 8 bits) / (10^6 bits per sec)

= 8.192 msec

Calculating Value of 'a'-

$a = T_p / T_t$

a = 1.25 sec / 8.192 msec

a = 152.59

Calculating Bits Required in Sequence Number Field-

Bits required in sequence number field

$= \lceil \log_2(1+2a) \rceil$

$= \lceil \log_2(1 + 2 \times 152.59) \rceil$

$= \lceil \log_2(306.176) \rceil$

$= \lceil 8.25 \rceil$

= 9 bits

Thus,

- Minimum number of bits required in sequence number field = 9
- With 9 bits, number of sequence numbers possible = 512.
- We use only (1+2a) sequence numbers and rest remains unused.

Problem-04:

Host A is sending data to host B over a full duplex link. A and B are using the sliding window protocol for flow control. The send and receive window sizes are 5 packets each. Data packets (sent only from A to B) are all 1000 bytes long and the transmission time for such a packet is 50 μs. Acknowledgement packets (sent only from B to A) are very small and require negligible transmission time. The propagation delay over the link is 200 μs. What is the maximum achievable throughput in this communication?

1. 7.69×10^6 Bps
2. 11.11×10^6 Bps
3. 12.33×10^6 Bps
4. 15.00×10^6 Bps

Solution-

Given-

- Sender window size = Receiver window size = 5
- Packet size = 1000 bytes
- Transmission delay (T_t) = 50 μs
- Propagation delay (T_p) = 200 μs

Calculating Bandwidth-

We know,

Transmission delay = Packet size / Bandwidth

So, Bandwidth

= Packet Size / Transmission delay (T_t)

= 1000 bytes / 50 μs

= (1000 x 8 bits) / (50×10^{-6} sec)

= 160 Mbps

Calculating Value of 'a'-

$a = T_p / T_t$

$a = 200\ \mu sec / 50\ \mu sec$

$a = 4$

Calculating Optimal Window Size-

Optimal window size

$= 1 + 2a$

$= 1 + 2 \times 4$

$= 9$

Calculating Efficiency-

Efficiency (η)

= Sender window size / Optimal window size

$= 5 / 9$

$= 0.5555$

$= 55.55\%$

Calculating Maximum Achievable Throughput-

Maximum achievable throughput

= Efficiency (η) x Bandwidth

= 0.5555 x 160 Mbps

= 88.88 Mbps

$= 88.88 \times 10^6$ bps or 11.11×10^6 Bps

Thus, Option (B) is correct.

Problem-05:

Station A uses 32 byte packets to transmit messages to station B using a sliding window protocol. The round trip delay between A and B is 80 msec and the bottleneck bandwidth on the path between A and B is 128 Kbps. What is the optimal window size that A should use?

1. 20
2. 40
3. 160
4. 320

Solution-

Given-

- Packet size = 32 bytes
- Round Trip Time = 80 msec
- Bandwidth = 128 Kbps

Calculating Transmission Delay-

Transmission delay (T_t)

= Packet size / Bandwidth

= 32 bytes / 128 Kbps

= (32 x 8 bits) / (128 x 10^3 bits per sec)

= 2 msec

Calculating Propagation Delay-

Propagation delay (T_p)

= Round Trip Time / 2

= 80 msec / 2

= 40 msec

Calculating Value of ‘a’-

$a = T_p / T_t$

a = 40 msec / 2 msec

a = 20

Calculating Optimal Window Size-

Optimal window size

= 1 + 2a

= 1 + 2 x 20

= 41 which is close to option (B)

Thus, Option (B) is correct.

PRACTICE PROBLEMS BASED ON GO BACK N PROTOCOL-

Problem-01:

A 20 Kbps satellite link has a propagation delay of 400 ms. The transmitter employs the “go back n ARQ” scheme with n set to 10.

Assuming that each frame is 100 bytes long, what is the maximum data rate possible?

1. 5 Kbps
2. 10 Kbps
3. 15 Kbps
4. 20 Kbps

Solution-

Given-

- Bandwidth = 20 Kbps
- Propagation delay (T_p) = 400 ms
- Frame size = 100 bytes
- Go back N is used where N = 10

Calculating Transmission Delay-

Transmission delay (T_t)

= Frame size / Bandwidth

= 100 bytes / 20 Kbps

= (100 x 8 bits) / (20 x 10^3 bits per sec)

= 0.04 sec

= 40 msec

Calculating Value Of 'a'-

a = T_p / T_t

a = 400 msec / 40 msec

a = 10

Calculating Efficiency-

Efficiency (η)

= N / (1+2a)

= 10 / (1 + 2 x 10)

= 10 / 21

= 0.476

= 47.6 %

Calculating Maximum Data Rate Possible-

Maximum data rate possible or Throughput

= Efficiency x Bandwidth

= 0.476 x 20 Kbps

= 9.52 Kbps

≅ 10 Kbps

Thus, Correct Option is (B)

Problem-02:

Consider the Go back N protocol with a sender's window size of 'n'. Suppose that at time 't', the next inorder packet the receiver is expecting has a sequence number of 'K'. Assume that the medium does not reorder messages.

Answer the following questions-

Part-01:

What are the possible sets of sequence numbers inside the sender's window at time 't'. Assume the sender has already received the ACKs.

1. [K-1, K+n-1]
2. [K, K+n-1]
3. [K, K+n]
4. [K+n, K-1]

Part-02:

If acknowledgements are still on their way to sender, what are all possible values of the ACK field in the messages currently propagating back to the sender at a time 't'?

1. [K-n, K-1]
2. [K-1, K-n]
3. [K, K-n]

4. [K-n, K+1]

Solution-

Part-01:

- In Go back N protocol, the receiver window size is 1.
- It is given that receiver expects the packet having sequence number ‘K’.
- It means it has processed all the packets ranging from 0 to K-1.
- It is given that sender has received the acknowledgement for all these packets.
- So, outstanding packets in sender’s window waiting for the acknowledgement starts from K.
- Sender window size = n.
- Therefore, last packet in sender’s window will have sequence number K+n-1.

Thus, Option (B) is correct.

Part-02:

- Acknowledgement number is the next expected sequence number by the receiver.
- Receiver expects the packet having sequence number ‘K’ at time ‘t’.
- It means it has received the packets ranging from 0 to K-1 whose acknowledgements are are on the way.
- For the $(K\text{-}1)^{th}$ packet, acknowledgement number would be ‘K’.
- For the $(K\text{-}2)^{th}$ packet, acknowledgement number would be ‘K-1’ and so on.

Now,

- At any time, maximum number of outstanding packets can be ‘n’.
- This is because sender’s window size is ‘n’.
- Therefore, the possible values of acknowledgement number ranges from [K-n+1, ……, K-3, K-2, K-1, K] (total n values)
- Here, we have assumed that the acknowledgement for all the packets are sent independently.

Thus, Option (C) is correct.

Problem-03:

Station A needs to send a message consisting of 9 packets to station B using a sliding window (window size 3) and go back n error control strategy. All packets are ready and immediately available for transmission.

If every 5th packet that A transmits gets lost (but no ACKs from B ever get lost), then what is the number of packets that A will transmit for sending the message to B?

1. 12
2. 14
3. 16
4. 18

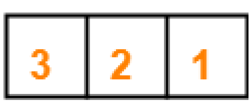
Solution-

Given-

- Total number of packets to be sent = 9
- Go back N is used where N = 3
- Every 5th packet gets lost

Step-01:

Since sender window size is 3, so sender sends 3 packets (1, 2, 3)-



Total packets sent till now from sender side = 3

Step-02:

After receiving the acknowledgement for packet-1, sender slides its window and sends packet-4.

4	3	2

Total packets sent till now from sender side = 4

Step-03:

After receiving the acknowledgement for packet-2, sender slides its window and sends packet-5.

5	4	3

Total packets sent till now from sender side = 5

Step-04:

After receiving the acknowledgement for packet-3, sender slides its window and sends packet-6.

6	5	4

Total packets sent till now from sender side = 6

Step-05:

After receiving the acknowledgement for packet-4, sender slides its window and sends packet-7.

7	6	5

Total packets sent till now from sender side = 7

Step-06:

- According to question, every 5th packet gets lost.
- So, packet-5 gets lost and when time out occurs, sender retransmits packet-5.
- In Go back N, all the following packets are also discarded by the receiver.
- So, packet-6 and packet-7 are discarded by the receiver and they are also retransmitted.
- Thus, the entire window is retransmitted.

So, we have-

7	6	5

Total packets sent till now from sender side = 10

Now, the next 5th packet that will be lost will be packet-7. (6, 7, 5, 6, 7)

Step-07:

After receiving the acknowledgement for packet-5, sender slides its window and sends packet-8.

8	7	6

Total packets sent till now from sender side = 11

Step-08:

After receiving the acknowledgement for packet-6, sender slides its window and sends packet-9.

9	8	7

Total packets sent till now from sender side = 12

Step-09:

- According to question, every 5th packet gets lost.
- So, packet-7 gets lost and when time out occurs, sender retransmits packet-7 and the following packets.
- Thus, the entire window is retransmitted.

So, we have-

9	8	7

Total packets sent till now from sender side = 15

Now, the next 5th packet that will be lost will be packet-9. (8, 9, 7, 8, 9)

Step-10:

After receiving the acknowledgement for packet-7, sender slides its window.

	9	8

Total packets sent till now from sender side = 15

Step-11:

After receiving the acknowledgement for packet-8, sender slides its window.

		9

Total packets sent till now from sender side = 15

Step-12:

- According to question, every 5th packet gets lost.
- So, packet-9 gets lost and when time out occurs, sender retransmits packet-9.

So, we have-

		9

Total packets sent till now from sender side = 16

Finally, all the 9 packets got transmitted which took total 16 number of transmissions.

Thus, Correct Option is (C).

Problem-04:

In Go back 4, if every 6th packet that is being transmitted is lost and if total number of packets to be sent is 10, then how many transmissions will be required?

Solution-

- Try yourself!
- We have to solve in exactly the same way as we have solved Problem-03.
- Total number of transmissions required will be 17.

Problem-05:

A 1 Mbps satellite link connects two ground stations. The altitude of the satellite is 36504 km and speed of the signal is 3×10^8 m/sec. What should be the packet size for a channel utilization of 25% for a satellite link using go back 127 sliding window protocol?

1. 120 bytes
2. 60 bytes
3. 240 bytes
4. 90 bytes

Solution-

Given-

- Bandwidth = 1 Mbps
- Distance = 2 x 36504 km = 73008 km
- Propagation speed = 3 x 10^8 m/sec
- Efficiency = 25% = 1/4
- Go back N is used where N = 127

Let the packet size be L bits.

Calculating Transmission Delay-

Transmission delay (T_t)

= Packet size / Bandwidth

= L bits / 1 Mbps

= L μsec

Calculating Propagation Delay-

Propagation delay (T_p)

= Distance / Speed

= (73008 x 10^3 m) / (3 x 10^8 m/sec)

= 24336 x 10^{-5} sec

= 243360 μsec

Calculating Value of 'a'-

a = T_p / T_t

a = 243360 μsec / L μsec

a = 243360 / L

Calculating Packet Size-

Efficiency (η) = N / (1+2a)

Substituting the values, we get-

1/4 = 127 / (1 + 2 x 243360 / L)

1/4 = 127 x L / (L + 486720)

L + 486720 = 508 x L

507 x L = 486720

L = 960

From here, packet size = 960 bits or 120 bytes.

Thus, Correct Option is (A).

Problem-06:

Consider a network connecting two systems located 8000 km apart. The bandwidth of the network is 500 x 10^6 bits per second. The propagation speed of the media is 4 x 10^6 meters per second. It is needed to design a Go back N sliding window protocol for this network. The average packet size is 10^7 bits. The network is to be used to its full capacity.

Assume that processing delays at nodes are negligible. Then, the minimum size in bits of the sequence number field has to be ______ ?

Solution-

Given-

- Distance = 8000 km
- Bandwidth = 500 x 10^6 bps
- Propagation speed = 4 x 10^6 m/sec
- Packet size = 10^7 bits

Now,

- For using the network to its full capacity, Efficiency (η) = 1
- Efficiency (η) = 1 when sender window size = 1+2a

Calculating Transmission Delay-

Transmission delay (T_t)

= Packet size / Bandwidth

= 10^7 bits / (500 x 10^6 bits per sec)

= 1 / 50 sec

= 0.02 sec

Calculating Propagation Delay-

Propagation delay (T_p)

= Distance / Speed

= 8000 km / (4 x 10^6 m/sec)

= 2 sec

Calculating Value of 'a'-

a = T_p / T_t

a = 2 sec / 0.02 sec

a = 100

Calculating Sender Window Size-

Sender window size

= 1 + 2a

= 1 + 2 x 100

= 201

Calculating Minimum Size Of Sequence Number Field-

Minimum number of bits required in the sequence number field

$= \lceil \log_2(1+2a) \rceil$

$= \lceil \log_2(201) \rceil$

$= \lceil 7.65 \rceil$

= 8

Thus, Minimum size of sequence number field = 8 bits.

PRACTICE PROBLEMS BASED ON SELECTIVE REPEAT PROTOCOL-

Problem-01:

The maximum window size for data transmission using the selective repeat protocol with n bit frame sequence numbers is-

1. 2^n
2. 2^{n-1}
3. 2^n-1
4. 2^{n-2}

Solution-

We know-

- With n bits, total number of sequence numbers possible = 2^n.
- In SR Protocol, sender window size = receiver window size = W (say)

For any sliding window protocol to work without any problems, Min Available Sequence Numbers

= Sender window size + Receiver window size

So, we have-

$$2^n = W + W$$

$$2^n = 2W$$

$$W = 2^{n-1}$$

Therefore, maximum window size possible of sender and receiver = 2^{n-1}

Thus, Option (B) is correct.

Problem-02:

In SR protocol, suppose frames through 0 to 4 have been transmitted. Now, imagine that 0 times out, 5 (a new frame) is transmitted, 1 times out, 2 times out and 6 (another new frame) is transmitted.

At this point, what will be the outstanding packets in sender's window?

1. 341526
2. 3405126
3. 0123456
4. 654321

Solution-

In SR Protocol, only the required frame is retransmitted and not the entire window.

Step-01:

Frames through 0 to 4 have been transmitted-

4 , 3 , 2 , 1 , 0

Step-02:

0 times out. So, sender retransmits it-

0 , 4 , 3 , 2 , 1

Step-03:

5 (a new frame) is transmitted-

5 , 0 , 4 , 3 , 2 , 1

Step-04:

1 times out. So, sender retransmits it-

1 , 5 , 0 , 4 , 3 , 2

Step-05:

2 times out. So, sender retransmits it-

2 , 1 , 5 , 0 , 4 , 3

Step-06:

6 (another new frame) is transmitted-

6 , 2 , 1 , 5 , 0 , 4 , 3

Thus, Option (B) is correct.

Problem-03:

The selective repeat protocol is similar to Go back N except in the following way-

1. Frame Formats are similar in both the protocols
2. The sender has a window defining maximum number of outstanding frames in both the protocols
3. Both uses piggybacked acknowledgements where possible and does not acknowledge every frame explicitly.
4. Both uses piggyback approach that acknowledges the most recently received frame

Solution-

Also Read- Go back N Protocol

Option (A)-

- Both the protocols use the same frame formats because both are sliding window protocols.
- The variation occurs only in the coding and implementation.

Option (B)-

- In both the protocols, sender has a window which defines the maximum number of outstanding frames.

Option (C)-

- Both the protocols use piggybacked acknowledgements wherever possible.
- Sending acknowledgements along with the data are called as **piggybacked acknowledgements**.
- But Go back N protocol uses cumulative acknowledgements and does not acknowledge every frame explicitly.
- On the other hand, Selective repeat protocol acknowledges each frame independently.

Option (D)-

- Both the protocols use piggyback approach.
- Go back N acknowledges the most recently received frame by sending a cumulative acknowledgement which includes the acknowledgement for previous packets too if any.
- On the other hand, Selective Repeat protocol acknowledges all the frames independently and not only the recently received frame.

Thus, Options (C) and (D) are correct.

Problem-04:

Consider a 128 x 10^3 bits/sec satellited communication link with one way propagation delay of 150 msec. Selective Retransmission (repeat) protocol is used on this link to send data with a frame size of 1 KB. Neglect the transmission time of acknowledgement. The minimum number of bits required for the sequence number field to achieve 100% utilization is ________ .

Solution-

Given-

- Bandwidth = 128 x 10^3 bits/sec
- Propagation delay (T_p) = 150 msec
- Frame size = 1 KB

Now,

- To achieve 100% utilization, efficiency must be 100%.
- Efficiency is 100% when sender window size is optimal i.e. 1+2a

Calculating Transmission Delay-

Transmission delay (T_t)

= Frame size / Bandwidth

= 1 KB / (128 x 10^3 bits per sec)

= (1 x 2^{10} x 8 bits) / (128 x 10^3 bits per sec)

= 64 msec

Calculating Value of 'a'-

$a = T_p / T_t$

a = 150 msec / 64 msec

a = 2.34

Calculating Optimal Sender Window Size-

Optimal sender window size

= 1 + 2a

= 1 + 2 x 2.34

= ⌈5.68⌉

= 6

Calculating Number Of Sequence Numbers Required-

In SR Protocol, sender window size and receiver window size are same.

So, sender window size = receiver window size = 6

Now,

For any sliding window protocol, minimum number of sequence numbers required

= Sender window size + Receiver window size

= 6 + 6

= 12

Calculating Bits Required in Sequence Number Field-

To have 12 sequence numbers,

Minimum number of bits required in sequence number field

$= \lceil \log_2(12) \rceil$

$= 4$

Thus,

- Minimum number of bits required in sequence number field = 4
- With 4 bits, number of sequence numbers possible = 16
- We use only 12 sequence numbers and rest 4 remains unused.

PRACTICE PROBLEMS BASED ON FLOW CONTROL PROTOCOLS-

Problem-01:

In what protocols is it possible for the sender to receive an acknowledgement for a packet that falls outside its current window?

1. Stop and Wait
2. Selective Repeat
3. Go back N
4. All of the above

Solution-

- Delayed Acknowledgements fall outside the current window.
- They may occur in any of the flow control protocols and received by the sender.

Thus, correct option is (D).

Problem-02:

On a wireless link, the probability of packet error is 0.2. A stop and wait protocol is used to transfer data across the link. The channel condition is assumed to be independent from transmission to transmission. What is the average number of transmission attempts required to transfer 100 packets?

1. 100
2. 125
3. 150
4. 200

Solution-

Method-01:

Given-

- Probability of packet error = 0.2
- We have to transfer 100 packets

Now,

- When we transfer 100 packets, number of packets in which error will occur = 0.2 x 100 = 20.
- Then, these 20 packets will have to be retransmitted.
- When we retransmit 20 packets, number of packets in which error will occur = 0.2 x 20 = 4.
- Then, these 4 packets will have to be retransmitted.
- When we retransmit 4 packets, number of packets in which error will occur = 0.2 x 4 = 0.8 ≅ 1.
- Then, this 1 packet will have to be retransmitted.

From here, average number of transmission attempts required = 100 + 20 + 4 + 1 = 125.

Thus, Option (B) is correct.

Method-02:

REMEMBER

If there are n packets to be transmitted and p is the probability of packet error, then-

Number of transmission attempts required

$= n + np + np^2 + np^3 + \ldots\ldots + \infty$

= n / (1-p)

Substituting the given values, we get-

Average number of transmission attempts required = 100 / (1-0.2) = 125.

Thus, Option (B) is correct.

Problem-03:

Compute the fraction of the bandwidth that is wasted on overhead (headers and retransmissions) for a protocol on a heavily loaded 50 Kbps satellite channel with data frames consisting of 40 bits header and 3960 data bits. Assume that the signal propagation time from the earth to the satellite is 270 msec. ACK frames never occur. NAK frames are 40 bits. The error rate for data frames is 1% and the error rate for NAK frames is negligible.

1. 1.21 %
2. 2.12 %
3. 1.99 %
4. 1.71 %

Solution-

Consider 100 frames are being sent. Then, we have-

Useful Data Sent-

Since each frame contains 3960 data bits, so while sending 100 frames,

Useful data sent

= 100 x 3960 bits

= 396000 bits

Useless Data Sent / Overhead-

In general, overhead is due to headers, retransmissions and negative acknowledgements.

Now,

- The error rate for data frames is 1%, therefore out of 100 sent frames, error occurs in one frame.
- This causes the negative acknowledgement to follow which causes the retransmission.

So, we have-

- Overhead due to headers = 100 x 40 bits = 400 bits.
- Overhead due to negative acknowledgement = 40 bits.
- Overhead due to retransmission = 40 bits header + 3960 data bits = 4000 bits.

From here,

Total overhead

= 400 bits + 40 bits + 4000 bits

= 8040 bits

Calculating Efficiency-

Efficiency (η) = Useful data sent / Total data sent

Here,

- Useful data sent = 396000 bits
- Total data sent = Useful data sent + Overhead = 396000 bits + 8040 bits = 404040 bits

Substituting the values, we get-

Efficiency (η)

= 396000 bits / 404040 bits

= 0.9801

Calculating Bandwidth Utilization-

Bandwidth Utilization

= Efficiency x Bandwidth

= 0.9801 x 50 Kbps

= 49.005 Kbps

Calculating Bandwidth Wasted-

Bandwidth wasted

= Bandwidth – Bandwidth Utilization

= 50 Kbps – 49.005 Kbps

= 0.995 Kbps

Calculating Fraction of Bandwidth Wasted-

Fraction of bandwidth wasted

= Wasted Bandwidth / Total Available Bandwidth

= 0.995 Kbps / 50 Kbps

= 0.0199

= 1.99 %

Thus, Option (C) is correct.

Problem-04:

Consider 1 Mbps error free line. The maximum frame size is 1000 bits. New packets are generated about 1 sec apart. The time out interval is 10 msec. If the ack timer is eliminated. How many times the average message be transmitted?

1. Only once
2. Twice
3. Thrice

4. Can’t say

Solution-

- Transmission delay (T_t) = L / B = 1000 bits / 10^6 bits per sec = 1 msec.
- After packet is put on the link, the time out timer is started which is 10 msec long.
- The next packet is transmitted after 1 sec = 1000 msec.
- If no acknowledgement is received within 10 msec, the packet will be retransmitted.
- We have been asked how many times the average message be transmitted i.e. how many retransmissions are possible.
- Retransmission occurs or not depends on the propagation delay (Tp).
- If T_p is more, time out will occur and retransmission will take place but if T_p is less, then there will be no time out.
- Since propagation delay (Tp) is not given in the question, therefore we can not say anything.

Thus, Option (D) is correct.

Problem-05:

What is the effect on line utilization if we increase the number of frames for a constant message size?

1. Lower line efficiency
2. Higher line efficiency
3. No change in line efficiency
4. No relation between line efficiency and frame size

Solution-

In both the following cases, line utilization remains the same-

- Whether the entire message is sent as a single entity
- Or the entire message is divided into frames and then frames are sent.

This is because line contains the same amount of data in both cases.

So,

- If the number of frames are increased by dividing the message, there is no change in line efficiency.
- The line efficiency remains the same.

Thus, Option (C) is correct.