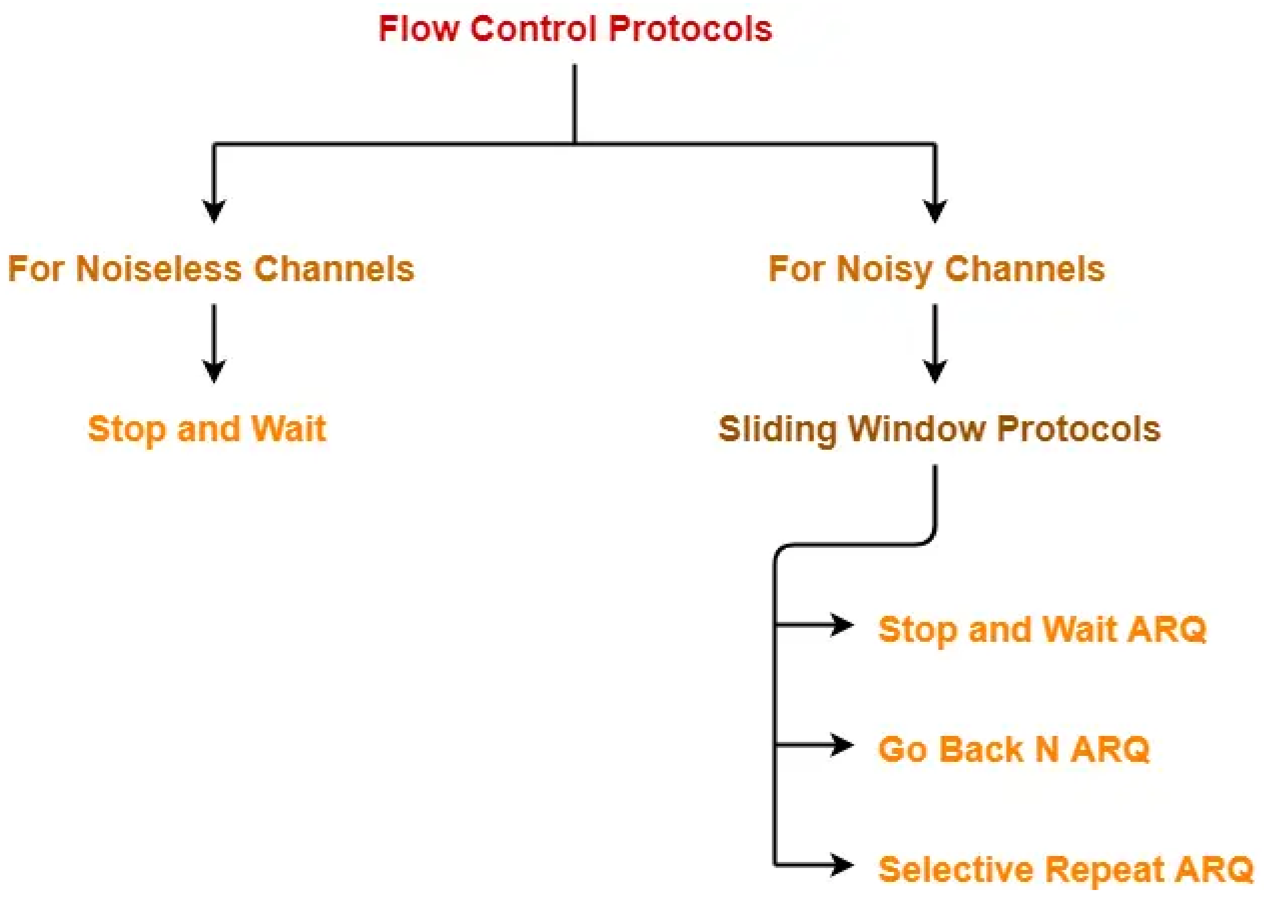
Flow Control | Stop and Wait Protocol

In computer networks, flow control is defined as-

A set of procedures which are used for restricting the amount of data that a sender can send to the receiver.

Flow Control Protocols-

There are various flow control protocols which are classified as-



Stop and Wait Protocol-

Stop and Wait Protocol is the simplest flow control protocol.

It works under the following assumptions-

Communication channel is perfect.

No error occurs during transmission.

Working-

The working of a stop and wait protocol may be explained as-

Sender sends a data packet to the receiver.

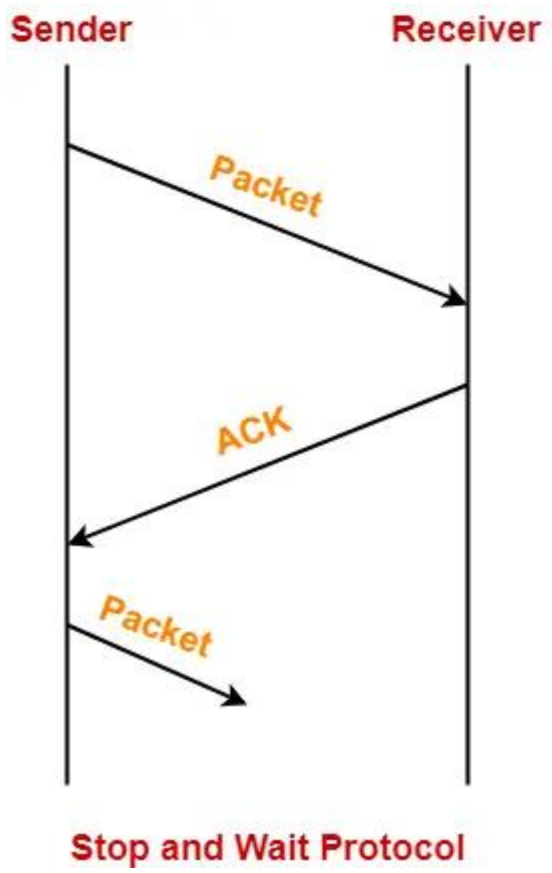
Sender stops and waits for the acknowledgement for the sent packet from the receiver.

Receiver receives and processes the data packet.

Receiver sends an acknowledgement to the sender.

After receiving the acknowledgement, sender sends the next data packet to the receiver.

These steps are illustrated below-

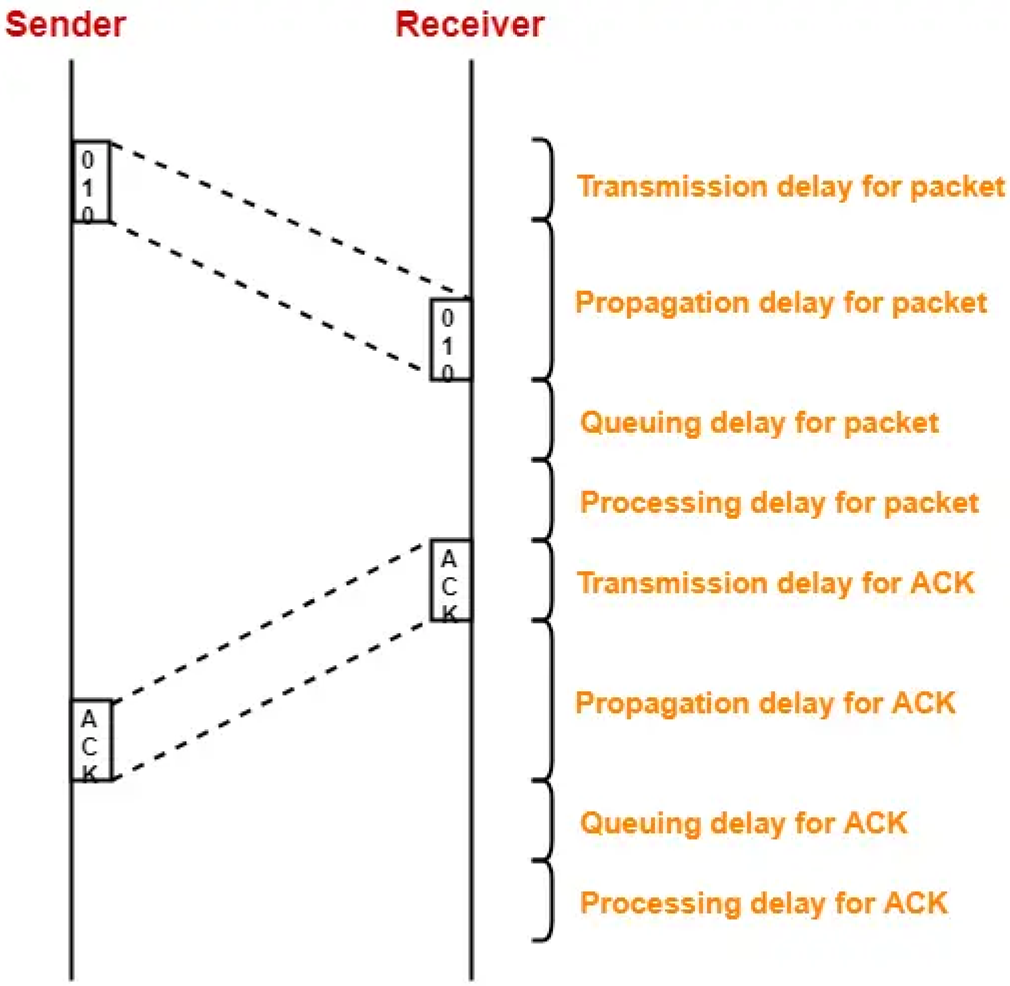


Analysis-

Now, let us analyse in depth how the transmission is actually carried out-

- Sender puts the data packet on the transmission link.
- Data packet propagates towards the receiver's end.
- Data packet reaches the receiver and waits in its buffer.
- Receiver processes the data packet.
- Receiver puts the acknowledgement on the transmission link.
- Acknowledgement propagates towards the sender's end.
- Acknowledgement reaches the sender and waits in its buffer.
- Sender processes the acknowledgement.

These steps are illustrated below-



Stop and Wait Protocol

Total Time-

Total time taken in sending one data packet

= (Transmission delay + Propagation delay + Queuing delay + Processing delay)$_{packet}$

+

(Transmission delay + Propagation delay + Queuing delay + Processing delay)$_{ACK}$

Assume-

- Queuing delay and processing delay to be zero at both sender and receiver side.
- Transmission time for the acknowledgement to be zero since it's size is very small.

Under the above assumptions.

Total time taken in sending one data packet

= (Transmission delay + Propagation delay)$_{packet}$ + (Propagation delay)$_{ACK}$

We know,

- Propagation delay depends on the distance and speed.
- So, it would be same for both data packet and acknowledgement.

So, we have-

Total time taken in sending one data packet

= (Transmission delay)$_{packet}$ + 2 x Propagation delay

Efficiency-

Efficiency of any flow control control protocol is given by-

Efficiency (η) = Useful Time / Total Time

where-

- Useful time = Transmission delay of data packet = (Transmission delay)$_{packet}$
- Useless time = Time for which sender is forced to wait and do nothing = 2 x Propagation delay
- Total time = Useful time + Useless time

$$\text{Efficiency } (\eta) = \frac{(\text{Transmission delay})_{packet}}{(\text{Transmission delay})_{packet} + 2 \times \text{Propagation delay}}$$

OR

$$\text{Efficiency } (\eta) = \frac{T_t}{T_t + 2T_p}$$

OR

$$\text{Efficiency } (\eta) = \frac{1}{1 + 2\left(\frac{T_p}{T_t}\right)}$$

OR

$$\text{Efficiency } (\eta) = \frac{1}{1 + 2a} \text{, where } a = \left(\frac{T_p}{T_t}\right)$$

Factors Affecting Efficiency-

We know,

Efficiency (η) = (Transmission delay)$_{packet}$ / { (Transmission delay)$_{packet}$ + 2 x Propagation delay }

Dividing numerator and denominator by (Transmission delay)$_{packet}$, we get-

$$\text{Efficiency } (\eta) = \frac{1}{1 + 2 \times \left(\frac{\text{Propagation delay}}{(\text{Transmission delay})_{packet}} \right)}$$

$$\text{Efficiency } (\eta) = \frac{1}{1 + 2 \times \left(\frac{\text{Distance}}{\text{speed}} \right) \times \left(\frac{\text{Bandwidth}}{\text{Packet length}} \right)}$$

From here, we can observe-

- Efficiency (η) ∝ 1 / Distance between sender and receiver
- Efficiency (η) ∝ 1 / Bandwidth
- Efficiency (η) ∝ Transmission speed
- Efficiency (η) ∝ Length of data packet

Throughput-

- Number of bits that can be sent through the channel per second is called as its throughput.

$$\boxed{\text{Throughput} = \text{Efficiency } (\eta) \times \text{Bandwidth}}$$

Round Trip Time-

Round Trip Time = 2 x Propagation delay

Advantages-

The advantages of stop and wait protocol are-

- It is very simple to implement.
- The incoming packet from receiver is always an acknowledgement.

Limitations-

The limitations of stop and wait protocol are-

Point-01:

- It is extremely inefficient because-
- It makes the transmission process extremely slow.

- It does not use the bandwidth entirely as each single packet and acknowledgement uses the entire time to traverse the link.

Point-02:

If the data packet sent by the sender gets lost, then-

- Sender will keep waiting for the acknowledgement for infinite time.
- Receiver will keep waiting for the data packet for infinite time.

Point-03:

If acknowledgement sent by the receiver gets lost, then-

- Sender will keep waiting for the acknowledgement for infinite time.
- Receiver will keep waiting for another data packet for infinite time.

Important Notes-

Note-01:

Efficiency may also be referred by the following names-

- Line Utilization
- Link Utilization
- Sender Utilization
- Utilization of Sender

Note-02:

Throughput may also be referred by the following names-

- Bandwidth Utilization
- Effective Bandwidth
- Maximum data rate possible
- Maximum achievable throughput

Note-03:

Stop and Wait protocol performs better for LANs than WANs.

This is because-

- Efficiency of the protocol is inversely proportional to the distance between sender and receiver.
- So, the protocol performs better where the distance between sender and receiver is less.
    - The distance is less in LANs as compared to WANs.