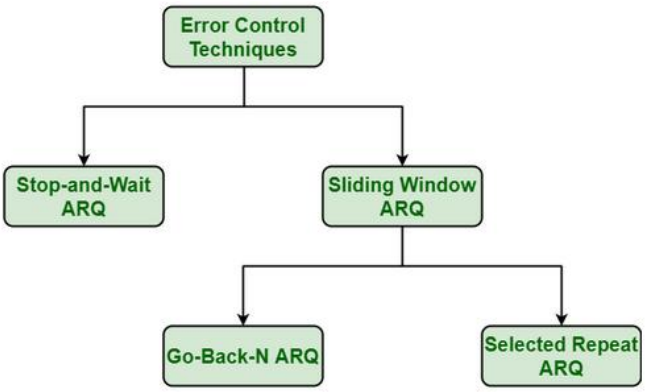
Error Control

Error control in data link layer is the process of detecting and correcting data frames that have been corrupted or lost during transmission. In case of lost or corrupted frames, the receiver does not receive the correct data-frame and sender is ignorant about the loss. Data link layer follows a technique to detect transit errors and take necessary actions, which is retransmission of frames whenever error is detected or frame is lost. The process is called Automatic Repeat Request (ARQ).
There are three main techniques for error control –



Automatic Repeat Request (ARQ)

Automatic Repeat Request (ARQ) is a group of error – control protocols for transmission of data over noisy or unreliable communication network. These protocols reside in the Data Link Layer and in the Transport Layer of the OSI (Open Systems Interconnection) reference model. They are named so because they provide for automatic retransmission of frames that are corrupted or lost during transmission. ARQ is also called Positive Acknowledgement with Retransmission (PAR).

Working Principle of ARQ

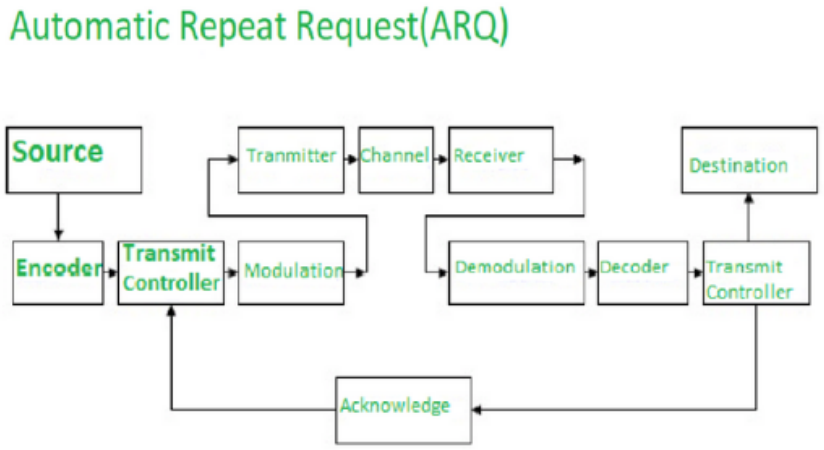
The main function of these protocols is, the sender receives an acknowledgement from the receiver end implying that the frame or packet is received correctly before a timeout occurs, timeout is a specific time period within which the acknowledgement has to be sent by the receiver to the sender. If a timeout occurs: the sender does not receive the acknowledgement before the specified time, it is implied that the frame or packet has been corrupt or lost during the transmission. Accordingly, the sender retransmits the packet and these protocols ensure that this process is repeated until the correct packet is transmitted.

Applications

ARQ protocols have a wide range of applications as they provide reliable transmissions over unreliable upper sources. These protocols are mainly functional on **shortwave radio** to ensure reliable delivery of signals.
For the same function of ARQ, there are various applications:

1. Transmission Control Protocol (TCP)
2. Specific Service Orientation Protocol: Error-correction of message signals in ATM networks.

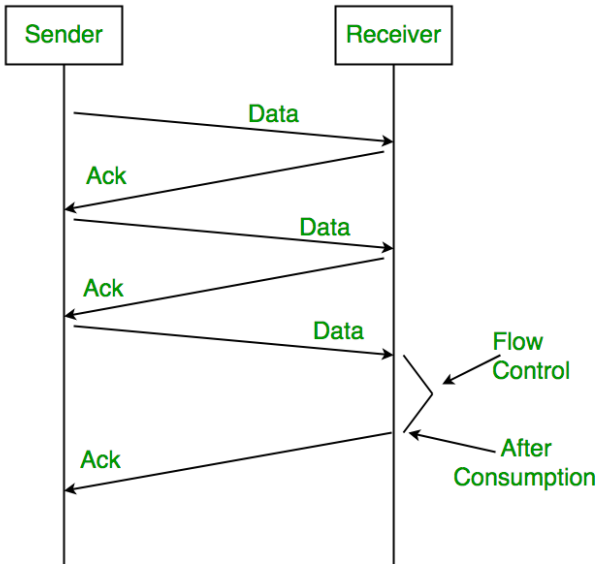
3. High-Level Data Link protocol.
4. IBM Binary synchronous Communications Protocol.
5. Xmodem : modem file transfer protocol.



Stop and Wait ARQ

This protocol involves the following transitions −

- A timeout counter is maintained by the sender, which is started when a frame is sent.
- If the sender receives acknowledgment of the sent frame within time, the sender is confirmed about successful delivery of the frame. It then transmits the next frame in queue.
- If the sender does not receive the acknowledgment within time, the sender assumes that either the frame or its acknowledgment is lost in transit. It then retransmits the frame.
- If the sender receives a negative acknowledgment, the sender retransmits the frame.

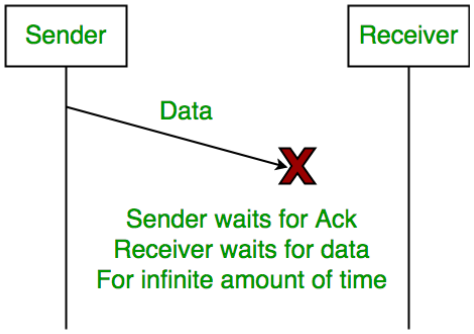


Characteristics of Stop and Wait ARQ:

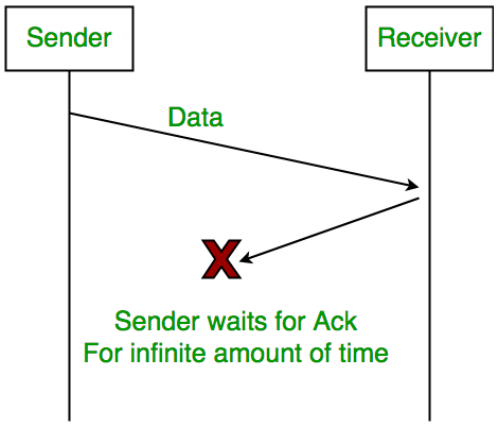
- It uses a link between sender and receiver as a half-duplex link
- Throughput = 1 Data packet/frame per RTT
- If the Bandwidth*Delay product is very high, then they stop and wait for protocol if it is not so useful. The sender has to keep waiting for acknowledgements before sending the processed next packet.
- It is an example for "**Closed Loop OR connection-oriented** " protocols
- It is a special category of SWP where its window size is 1
- Irrespective of the number of packets sender is having stop and wait for protocol requires only 2 sequence numbers 0 and 1

Problems in Stop and Wait ARQ:

1. **Lost Data**



2. **Lost Acknowledgement:**



3. **Delayed Acknowledgement/Data:** After a timeout on the sender side, a long-delayed acknowledgement might be wrongly considered as acknowledgement of some other recent packet.

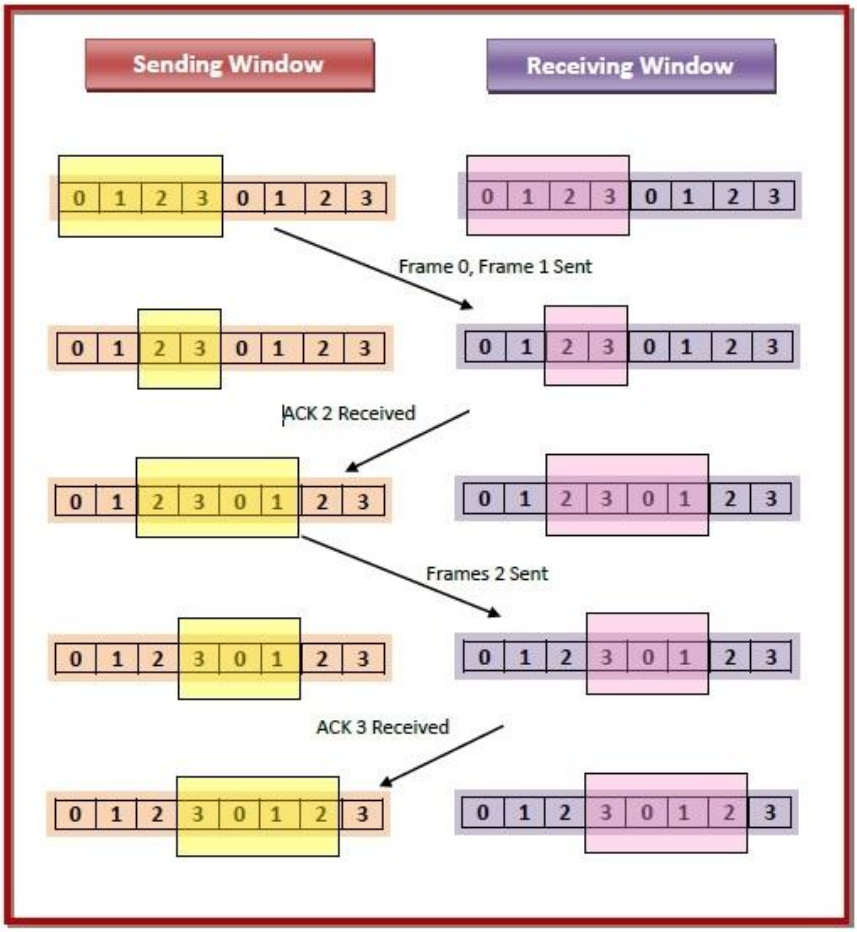
Sliding Window Protocol

Sliding window protocols are data link layer protocols for reliable and sequential delivery of data frames. The sliding window is also used in Transmission Control Protocol. In this protocol, multiple frames can be sent by a sender at a time before receiving an acknowledgment from the receiver. The term sliding window refers to the imaginary boxes to hold frames.

In these protocols, the sender has a buffer called the sending window and the receiver has buffer called the receiving window. The size of the sending window determines the sequence number of the outbound frames. If the sequence number of the frames is an n-bit field, then the range of sequence numbers that can be assigned is 0 to 2^n-1. Consequently, the size of the sending window is 2^n-1. Thus in order to accommodate a sending window size of 2^n-1, a n-bit sequence number is chosen.

Example

Suppose that we have sender window and receiver window each of size 4. So the sequence numbering of both the windows will be 0,1,2,3,0,1,2 and so on. The following diagram shows the positions of the windows after sending the frames and receiving acknowledgments.

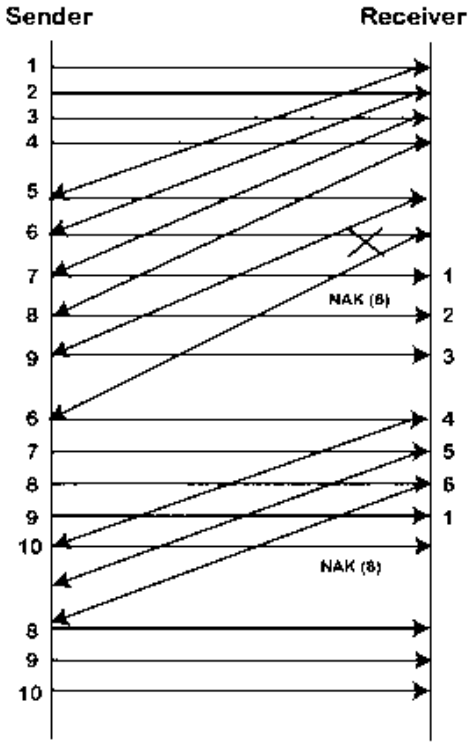


Types of Sliding Window Protocols

Go-Back-N ARQ

The working principle of this protocol is −

- The sender has buffers called sending window.
- The sender sends multiple frames based upon the sending-window size, without receiving the acknowledgment of the previous ones.
- The receiver receives frames one by one. It keeps track of incoming frame's sequence number and sends the corresponding acknowledgment frames.
- After the sender has sent all the frames in window, it checks up to what sequence number it has received positive acknowledgment.
- If the sender has received positive acknowledgment for all the frames, it sends next set of frames.
- If sender receives NACK or has not receive any ACK for a particular frame, it retransmits all the frames after which it does not receive any positive ACK.

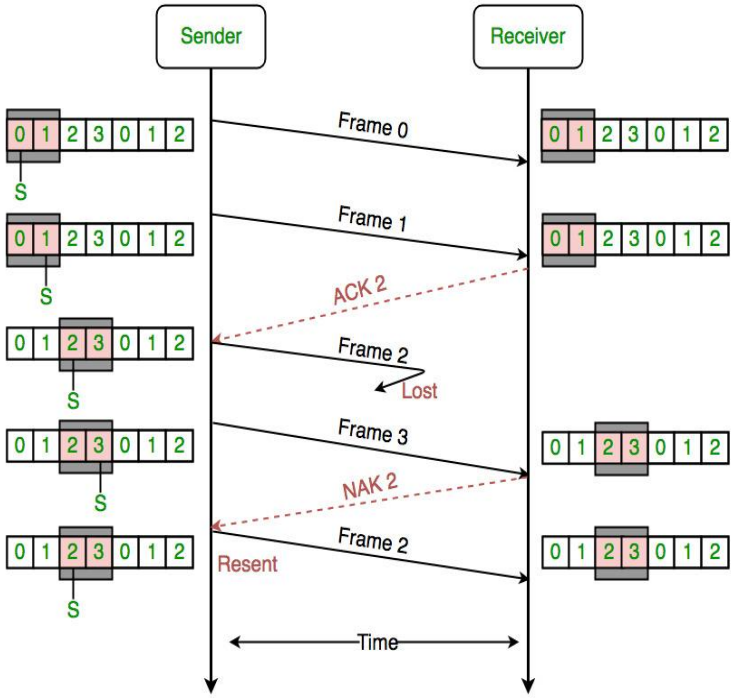


Selective Repeat ARQ:

Selective Repeat ARQ is a data link layer protocol that uses a sliding window method. The Go-back-N ARQ protocol works well if it has fewer errors. But if there is a lot of error in the frame, lots of bandwidth loss in sending the frames again. So, we use the Selective Repeat ARQ protocol. In this protocol, the size of the sender window is always equal to the size of the receiver window. The size of the sliding window is always greater than 1.

If the receiver receives a corrupt frame, it does not directly discard it. It sends a negative acknowledgment to the sender. The sender sends that frame again as soon as on the receiving negative acknowledgment. There is no waiting for any time-out to send that frame.

In Selective Repeat ARQ only the lost or error frames are retransmitted, whereas correct frames are received and buffered. The receiver while keeping track of sequence numbers buffers the frames in memory and sends NACK for only frames which are missing or damaged. The sender will send/retransmit a packet for which NACK is received.



Difference between the Go-Back-N ARQ and Selective Repeat ARQ:

Go-Back-N ARQ	Selective Repeat ARQ
If a frame is corrupted or lost in it,all subsequent frames have to be sent again.	In this, only the frame is sent again, which is corrupted or lost.
If it has a high error rate,it wastes a lot of bandwidth.	There is a loss of low bandwidth.
It is less complex.	It is more complex because it has to do sorting and searching as well. And it also requires more storage.
It does not require sorting.	In this, sorting is done to get the frames in the correct order.
It does not require searching.	The search operation is performed in it.
It is used more.	It is used less because it is more complex.

Difference between go back n ARQ and stop and wait ARQ:

Stop and Wait protocol	Go Back N protocol
In Stop and Wait protocol, Sender window size is 1.	In GoBackN protocol, Sender window size is N.
In Stop and Wait protocol, Receiver window size is 1.	In GoBackN protocol, Receiver window size is 1.
In Stop and Wait protocol, Minimum Sequence Number is 2.	In GoBackN protocol, Minimum Sequence Number is N+1 where N is number of packets sent.
In Stop and Wait protocol, Efficiency formular is 1/(1+2*a) where a is ratio of propagation delay vs transmission delay.	In GoBackN protocol, Efficiency formular is N/(1+2*a) where a is ratio of propagation delay vs transmission delay and N is number of packets sent.
In Stop and Wait protocol, Acknowledgement type is individual.	In GoBackN protocol, Acknowledgement type is cumulative.
In Stop and Wait protocol, no specific order is needed at receiver end.	In GoBackN protocol, in-order delivery only are accepted at receiver end.
In Stop and Wait protocol, in case of packet drop,number of retransmition is 1.	In GoBackN protocol, in case of packet drop,numbers of retransmitions are N.