Data Link Layer Design Issues

- Services Provided to the Network Layer
- Framing
- Error Control
- Flow Control

Flow control

- Flow control is a set of procedures that tells the sender how much data it can transmit before it must wait for an acknowledgment from the receiver.
- The flow of data must not be allowed to overwhelm the receiver.
- Any receiving device has a limited speed at which it can process incoming data and a limited amount of memory in which to store incoming data.

CATEGORIES OF FLOW CONTROL

- **Stop-and-Wait Protocol**
- **Sliding Window Protocol**

Stop-and-Wait Protocol

- Protocols in which the sender sends one frame and then waits for an acknowledgment before proceeding are called ***Stop-and-Wait Protocol***
- source sends a packet and only after receiving the acknowledgment from the destination, it sends next packet.
- simple protocol, but it results in lots of delay, and the bandwidth is not used efficiently.
- When the source (end system A) sends the first packet to the destination (end system B) and waits for the acknowledgment, then B sends an acknowledgement packet.
- Then A sends the second packet, and B sends the acknowledgement. A repeat this process until sender A transmit an end of transmission frame (EOT).

Stop-and-Wait Protocol

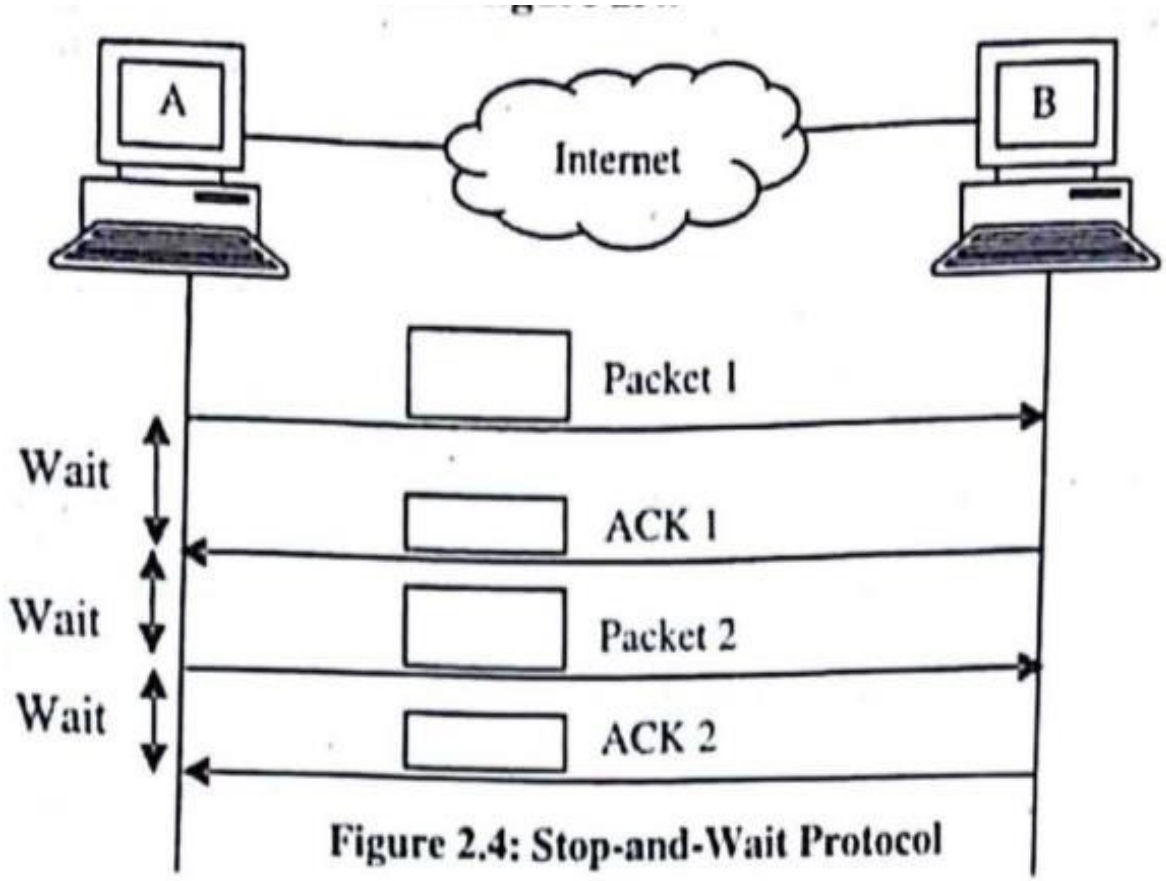


Figure 2.4: Stop-and-Wait Protocol

Stop-and-Wait Protocol

Advantages

- It is a very simple protocol of flow control.
- The next frame is sent only when the first frame is acknowledged. So, there is no chance of any frame being lost.

Disadvantages

- Only single frame is transmitted which makes the protocol inefficient
- Throughput is very poor and the channel bandwidth is not used efficiently.

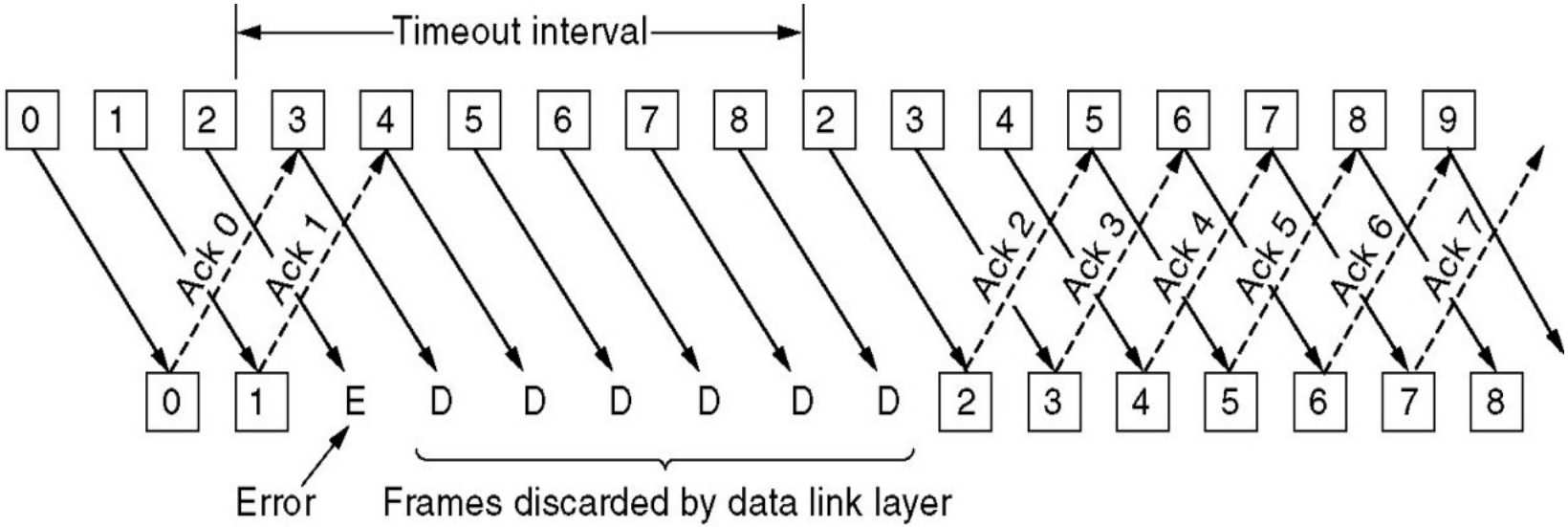
Sliding Window Protocol

- In the elementary data link protocols, data frames are transmitted in one direction only but there is a need to transmitting data in both directions.
- This is achieved by sliding window protocol.
- In the sliding window method, the sender can transmit several frames before getting an acknowledgment.
- Frames can be sent one after another, meaning that the link can carry several frames at once and its capacity can be used efficiently.

Types of Sliding Window Protocol

- Go-Back-N Protocol
- Selective Repeat Protocol

Go-Back-N Protocol

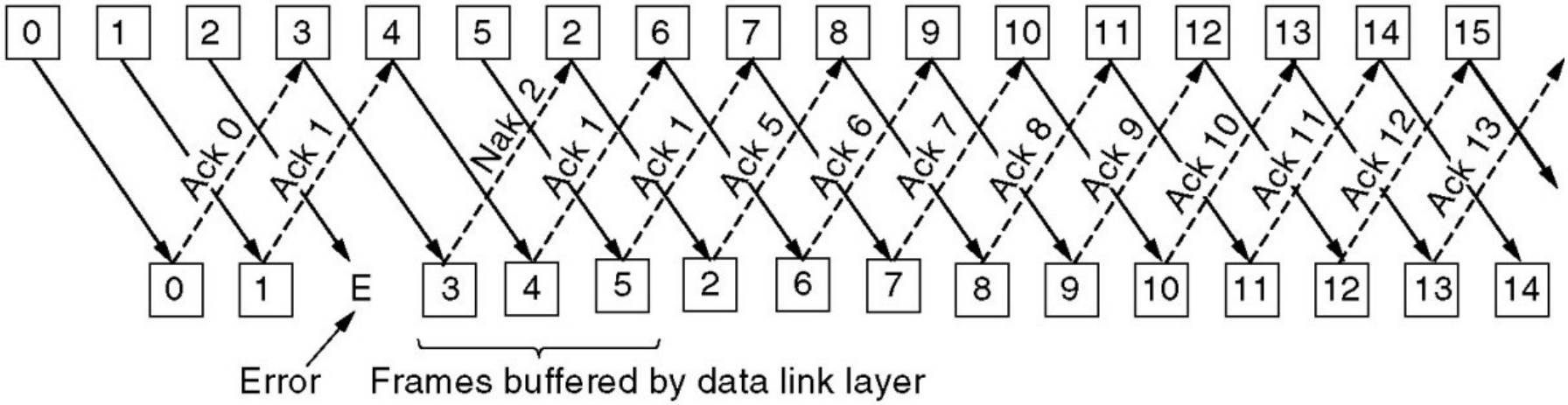


- Frames 0 and 1 are correctly received and acknowledged.
- Frame 2, however, is damaged or lost.
- The sender, unaware of this problem, continues to send frames until the timer for frame 2 expires.
- Then it backs up to frame 2 and starts all over with it, sending 2, 3, 4, etc. all over again

Selective Repeat

- When it is used, a bad frame that is received is discarded, but good frames received after it are buffered.
- When the sender times out, only the oldest unacknowledged frame is retransmitted

Selective Repeat



- Frames 0 and 1 are again correctly received and acknowledged and frame 2 is lost.
- When frame 3 arrives at the receiver, the DLL notices that is has missed a frame
- So it sends back a NAK for 2 but buffers 3.
- When frames 4 and 5 arrive, they, too, are buffered by the DLL instead of being passed to the network layer.
- Eventually, the NAK 2 gets back to the sender, which immediately resends frame 2. When that arrives, the DLL now has 2, 3, 4, and 5 and can pass all of them to the network layer in the correct order.
- It can also acknowledge all frames up to and including 5

Sliding Window Protocol

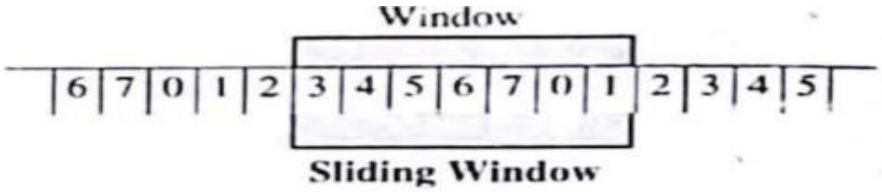
- In the sliding window method protocol, several frames can be in transmit at a time.
- The sliding window refers to imaginary boxes at both the sender and receiver.
- This window can hold frames at either end and provides the upper limit on the number of frames that can be transmitted before requiring an acknowledgment.

Sliding Window Protocol

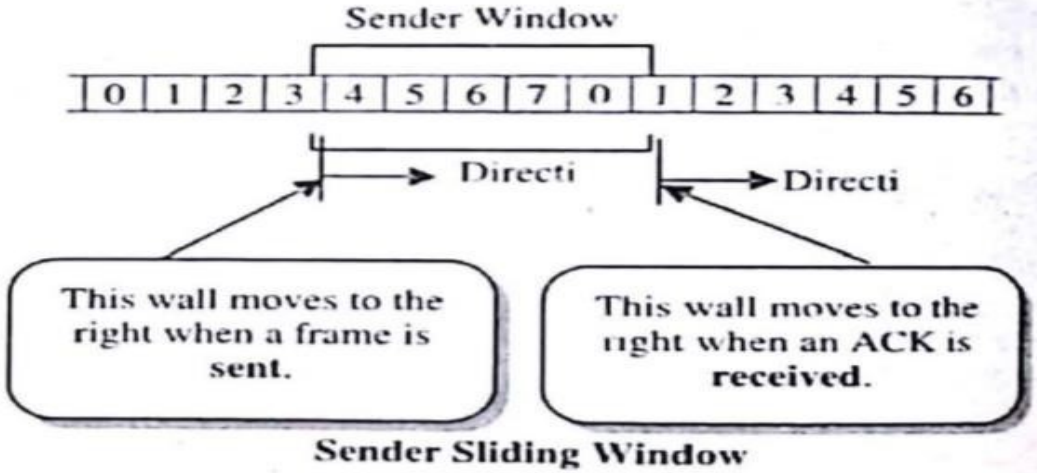
- The sender maintains information about
  - Size of sender window
  - Last frame sent
  - Last acknowledgement received

The receiver acknowledges only some of the frames, using a single ACK to confirm the receipt of multiple data frames.

- Receiver holds information about
  - Size of Receiver window
  - Last frame received



Sliding Window



Sender Sliding Window

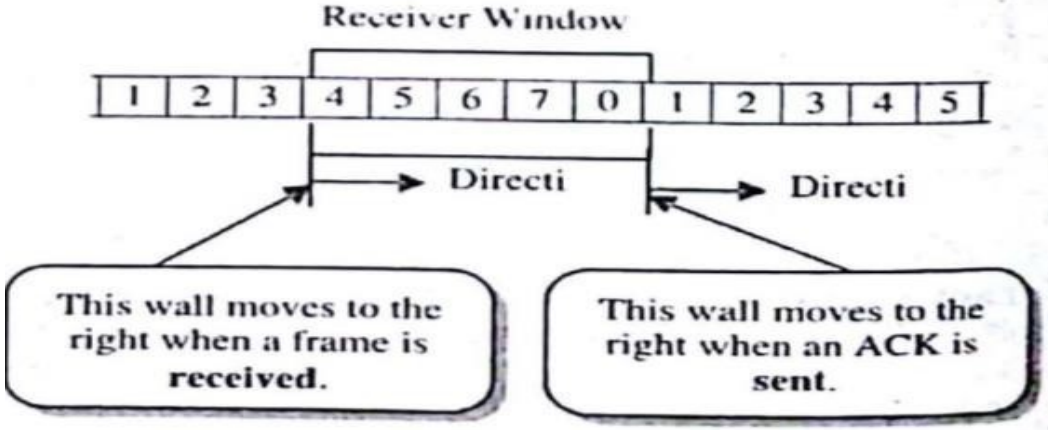


Figure 2.5: Receiver Sliding Window

Sliding Window Protocol

- **Advantages**
  - Network Utilization
  - Data can be transmitted in both directions.
  - Several frames can be in transit at a time.

- **Disadvantages**
  - complexity and hardware capacity
  - The window can hold n-1 frames at either end. therefore, a minimum of n-1 frame may be cut before an acknowledgment is required

AUTOMATIC REPEAT REQUEST (ARQ)

- an error-control method for data transmission that uses acknowledgements (messages sent by the receiver indicating that it has correctly received a data frame or packet) and timeouts (specified periods of time allowed to elapse before an acknowledgment is to be received) to achieve reliable data transmission over an unreliable service
- If the sender does not receive an acknowledgment before the timeout, it usually re-transmits the frame/packet until the sender receives an acknowledgment or exceeds a predefined number of re-transmissions.
- The receiver will send back an ARQ message to the transmitter to indicate that the last block should be retransmitted

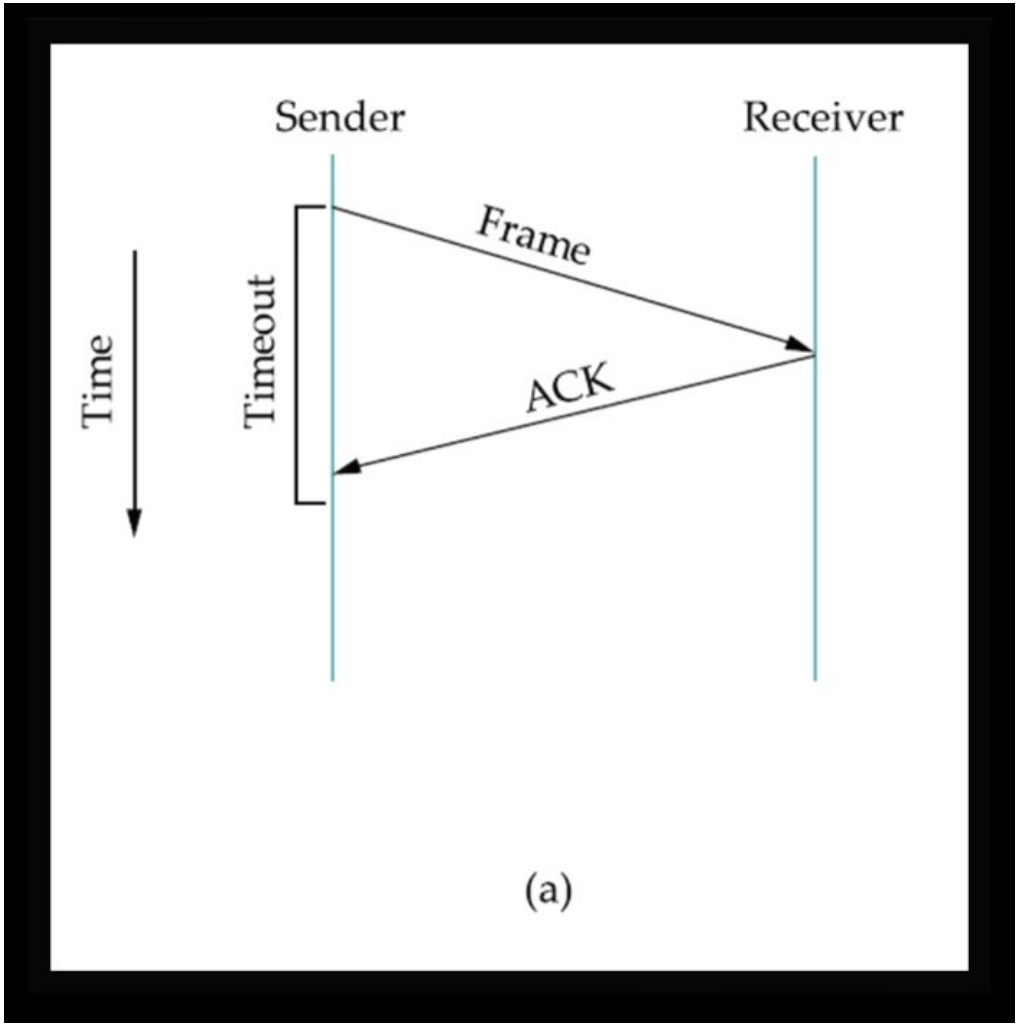
CATEGORIES OF AUTOMATIC REPEAT REQUEST

- **Stop-and-Wait ARQ**
- **Sliding Window ARQ**

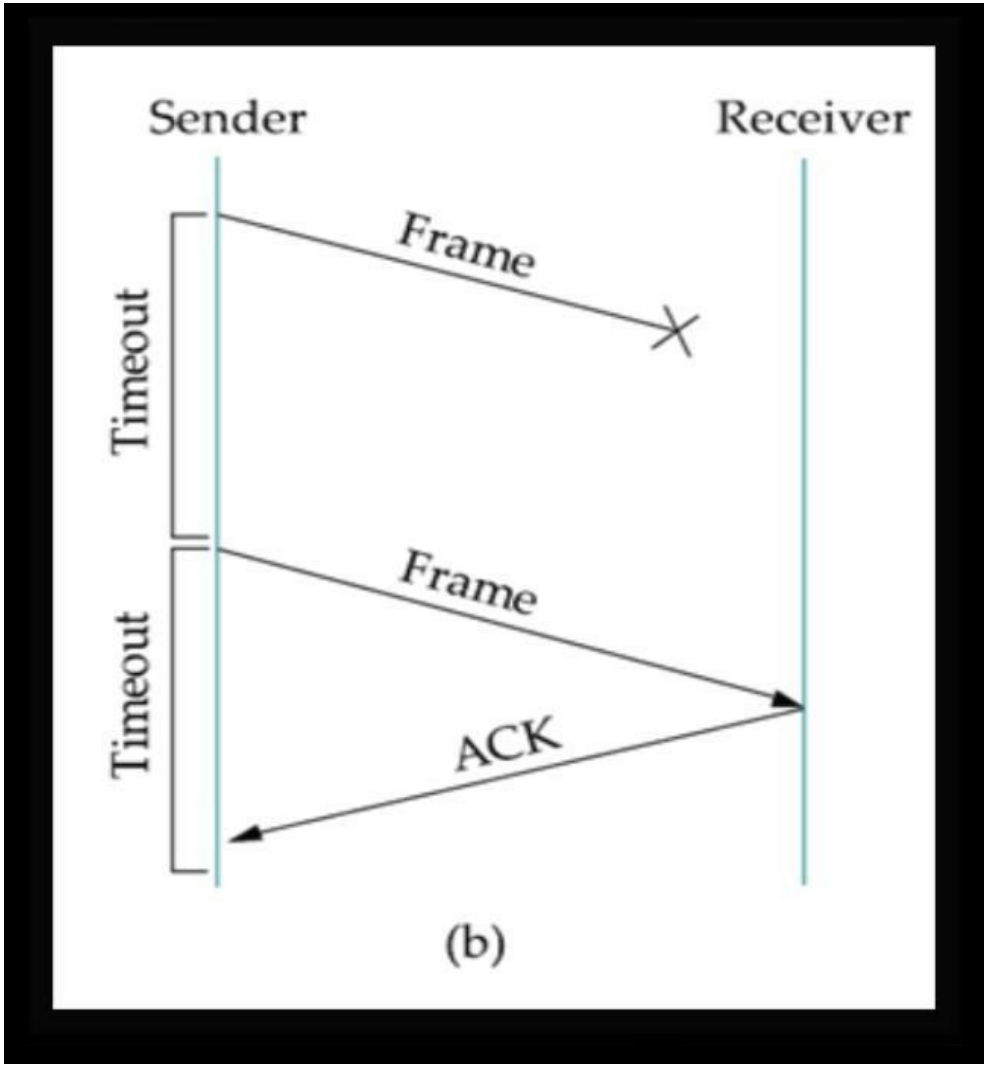
Stop-and-Wait ARQ

- Stop-and-wait ARQ is a form of stop-and-wait flow control extended to include retransmission of data in case of lost or damaged frames
- After transmitting one frame, the sender waits for an acknowledgment before transmitting the next frame.
- If the acknowledgment does not arrive after a certain period of time, the sender times out and retransmits the original frame.

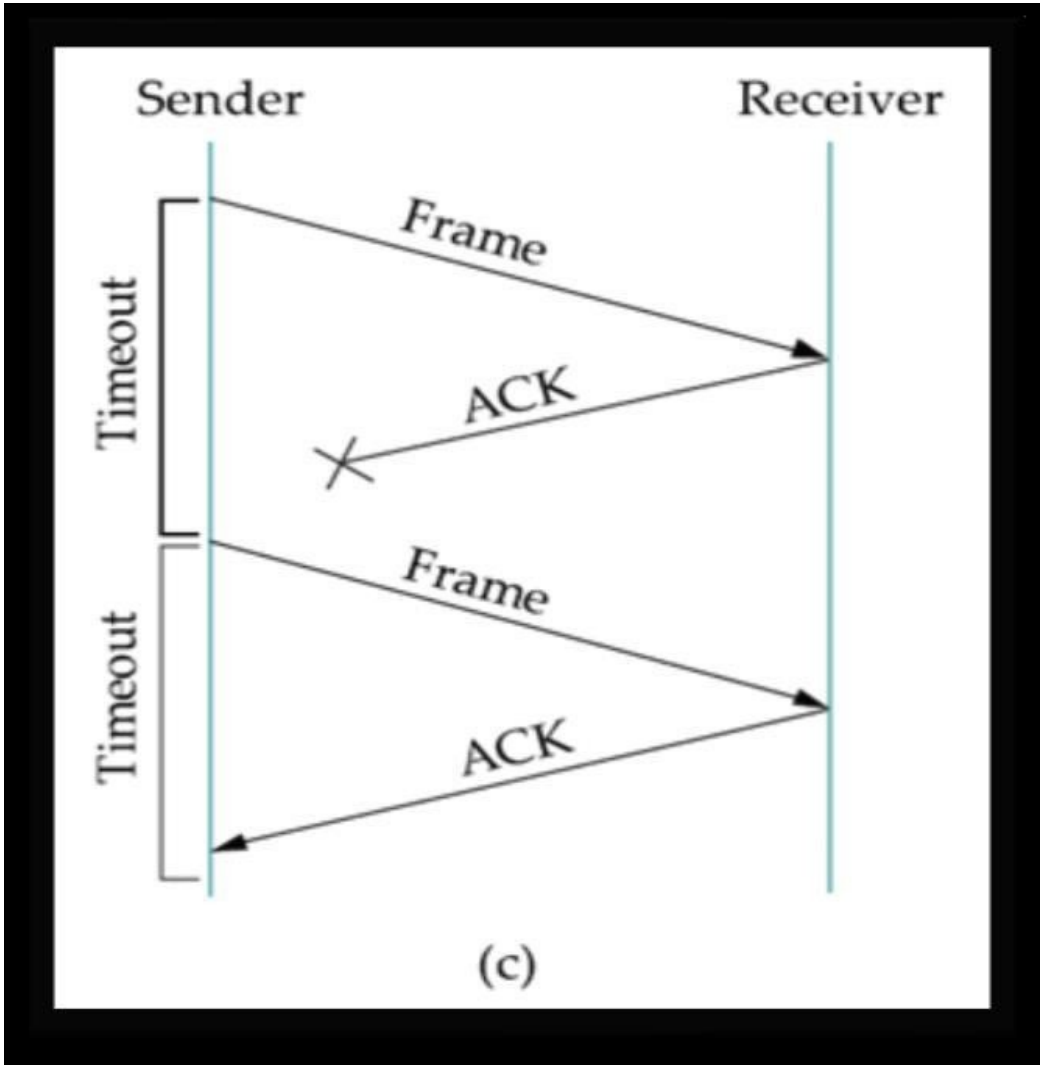
ACK is received before the timer expires



original frame lost



ACK lost



Advantages & Disadvantages

Advantages of Stop-and-Wait ARQ

- It has both error and flow control mechanism
- It has timer implementation
- Easy to implement
- Low buffer requirement

Disadvantages of Stop-and-Wait ARQ

- **Efficiency is very less**
- **Timer should be set for each individual frame**
- **Sender window size is 1**
- **Receiver window size is 1**

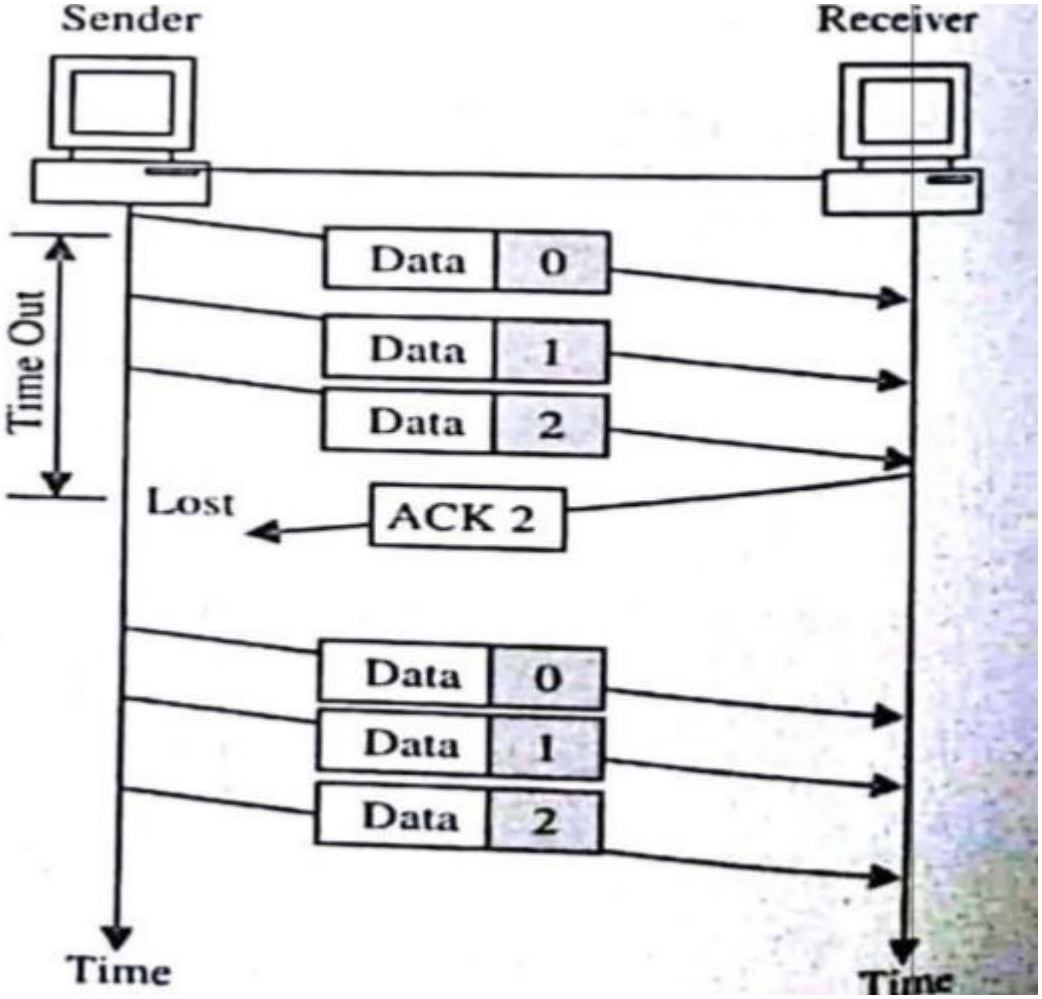
Sliding Window ARQ

- Go-Back-n ARQ
- Selective-Repeat ARQ

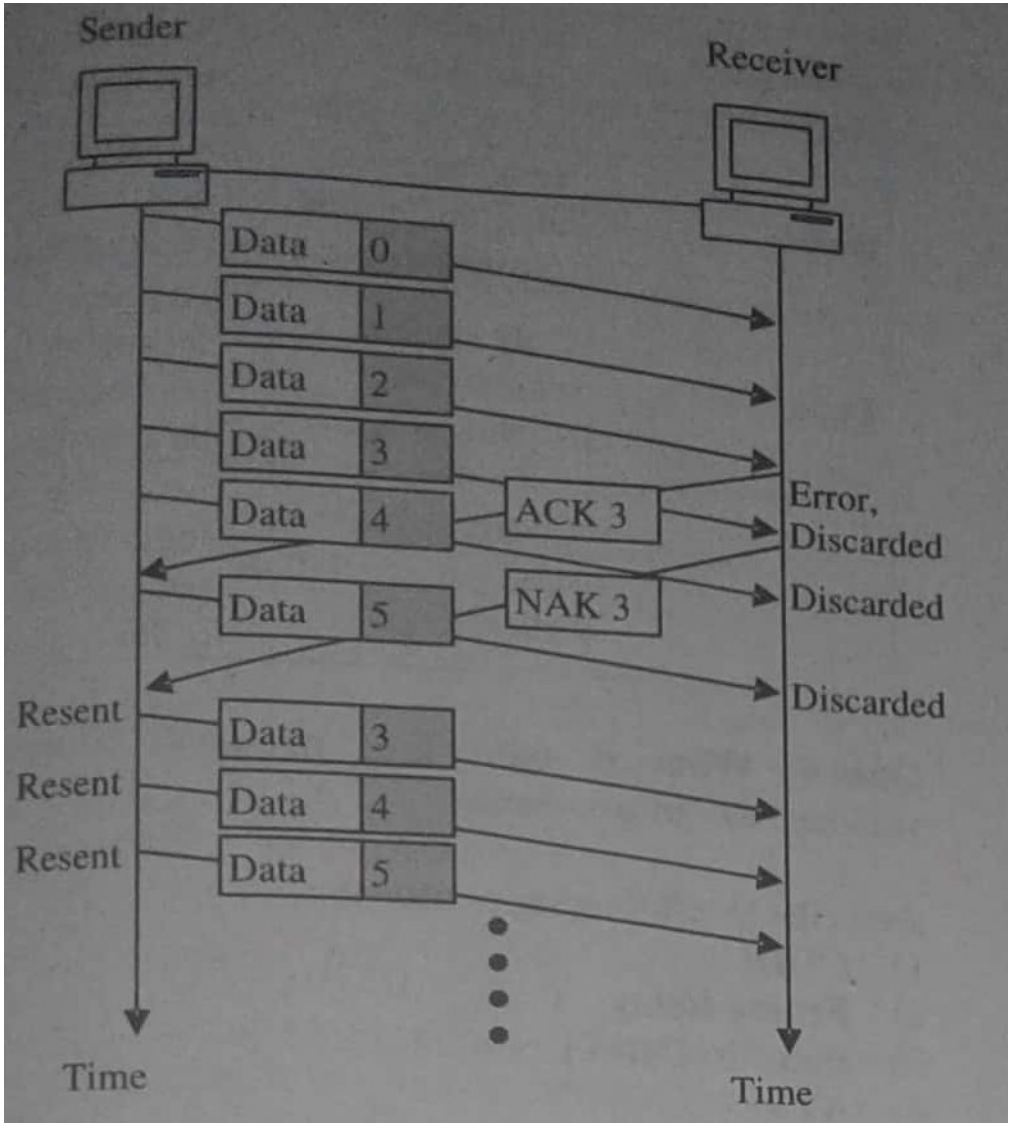
Go-Back-n ARQ

- sending process continues to send a number of frames specified by a window size even without receiving an acknowledgement (ACK) packet from the receiver.
- When the receiver finds a frame in error,it tells the sender to resend that frame and all succeeding frames
- Cumulative acknowledgment : so for all data only 1 acknowledgment is passed. Traffic is less. But if the any data lost then acknowledgment is not given.

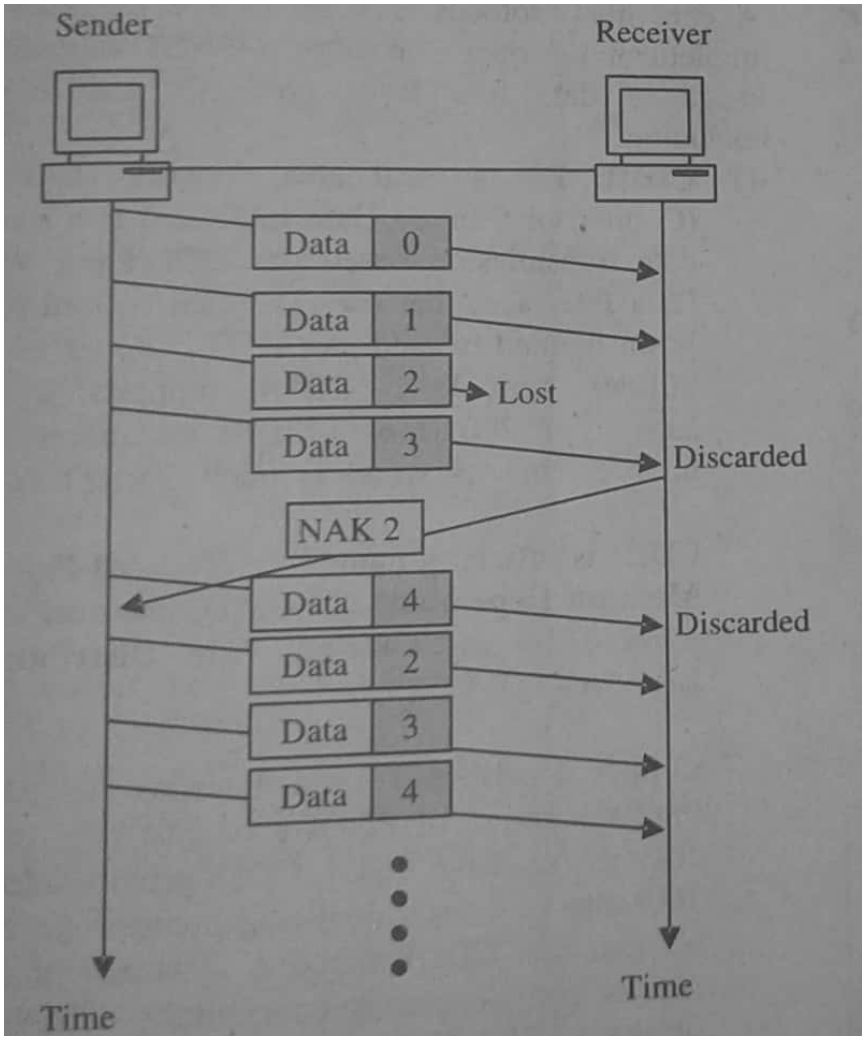
Go-Back-n ARQ(Lost Ack)



Go-Back-n ARQ(**Damaged Frame**)



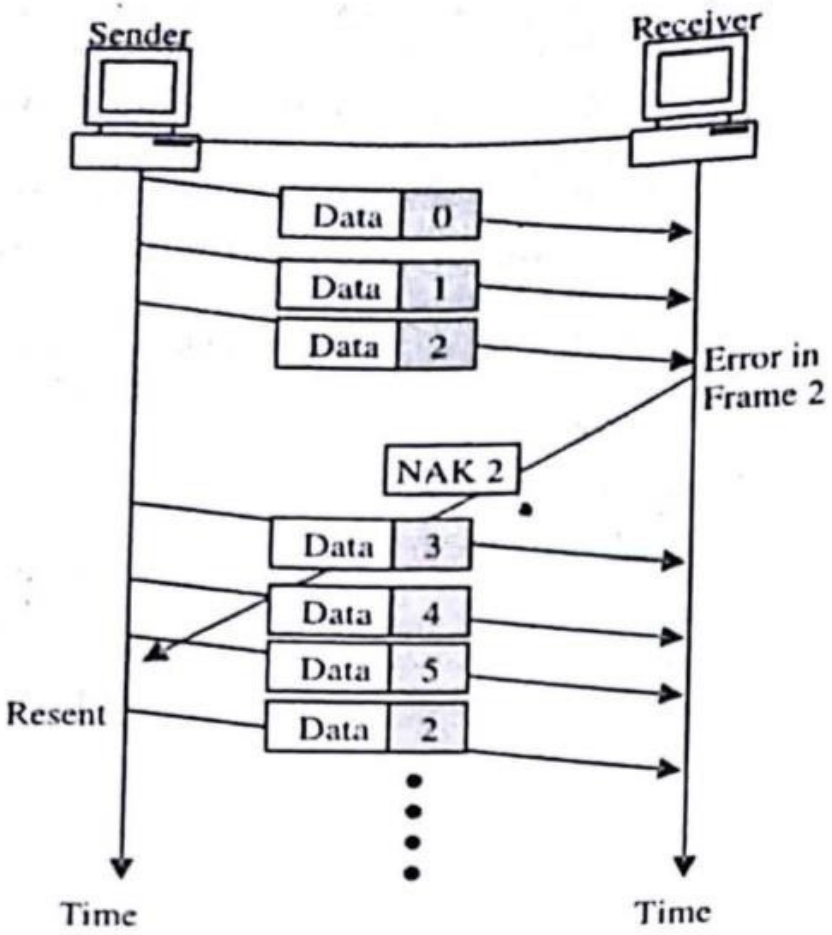
Go-Back-n ARQ(**Lost Data Frame**)



Selective Repeat ARQ

- sender sends a number of frames specified by a window size even without the need to wait for individual ACK from the receiver as in stop-and wait.
- However, the receiver sends ACK for each frame individually, which is not like cumulative ACK as used with go-back-n.
- The receiver accepts out-of-order frames and buffers them.
- The sender individually retransmits frames that have timed out.
- In selective-repeat ARQ, only the specific damaged or lost frame is retransmitted.
- If a frame is corrupted in transit, a NAK is returned and the frame is resent out of sequence.
- The receiving device must be able to sort the frames it has and insert the retransmitted frame into its proper place in the sequence.

Selective-Repeat ARQ



ure 2.13: Selective Repeat, Damaged Data Frame

Advantages &Disadvantages

Advantages

- Similar to Go-Back-N ARQ. However, the sender only retransmits frames for which a NAK is received.
- Fewer retransmission

Disadvantages of Selective-Repeat ARQ

- More complexity at sender and receiver
- Each frame must be acknowledged individually
- Receiver may receive frames out of sequence