DATA LINK LAYER DESIGN ISSUES

Specific functions of data link layer are:

(a) Providing a well-defined service interface to N/w layer.
(b) Dealing with transmission errors
(c) Regulating the flow of data so that slow receivers are not swamped by fast senders.

Services Provided to Network Layer

Principal service of data link layer is transferring data from N/w layer on the source m/c to n/w layer on destination machine.

Three reasonable possible services which data link layer can provide are :-

(a) Unacknowledged connectionless service

No logical connection is established. If frame is lost due to noise on the line, no attempt is made to detect the loss or recover the frame.
This service is appropriate when error rate is very low. Most LANs use this service

(b) Acknowledged connectionless service

Each frame sent is acknowledged.

(c) Acknowledged connection-oriented service.

Source & destination establish a connection, before sending data. Each frame is numbered & guarantees that it is received & received only once.

layer.

Data link layer divides the stream of bits received from N/w layer into manageable data units called frames. How frames are formed is a design issue. Header is added to frame to define addresses of sender & receiver. Flow control is required to prevent overwhelming of receiver.

Data link layer also adds reliability to physical layer by adding mechanisms to detect & retransmit damaged, duplicate or lost frames. (Error Control)

Media Access Control when 2 or more devices are connected to same link, data link layer protocols are necessary to determine which device has control over the link at any given time.

Specific responsibilities of data link layer are framing, addressing, flow control, error control & media access control.

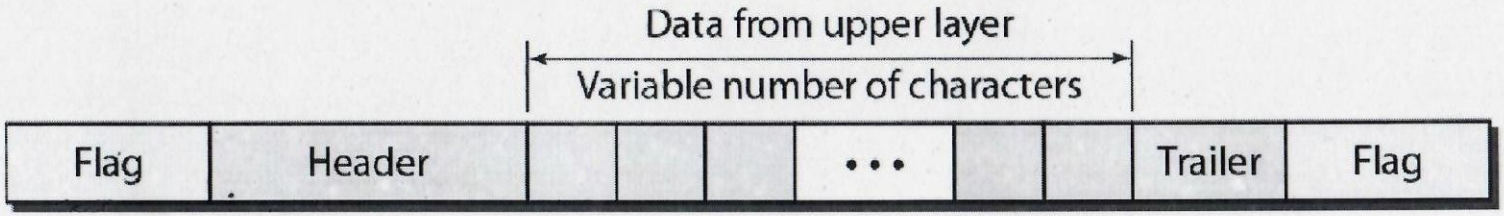
FRAMING

The data link layer needs to pack bits into frames, so that each frame is distinguishable from another. Our postal system practices a type of framing. The simple act of inserting a letter into an envelope separates one piece of information from another; the envelope serves as the delimiter.

<u>Two types of framing are:</u>

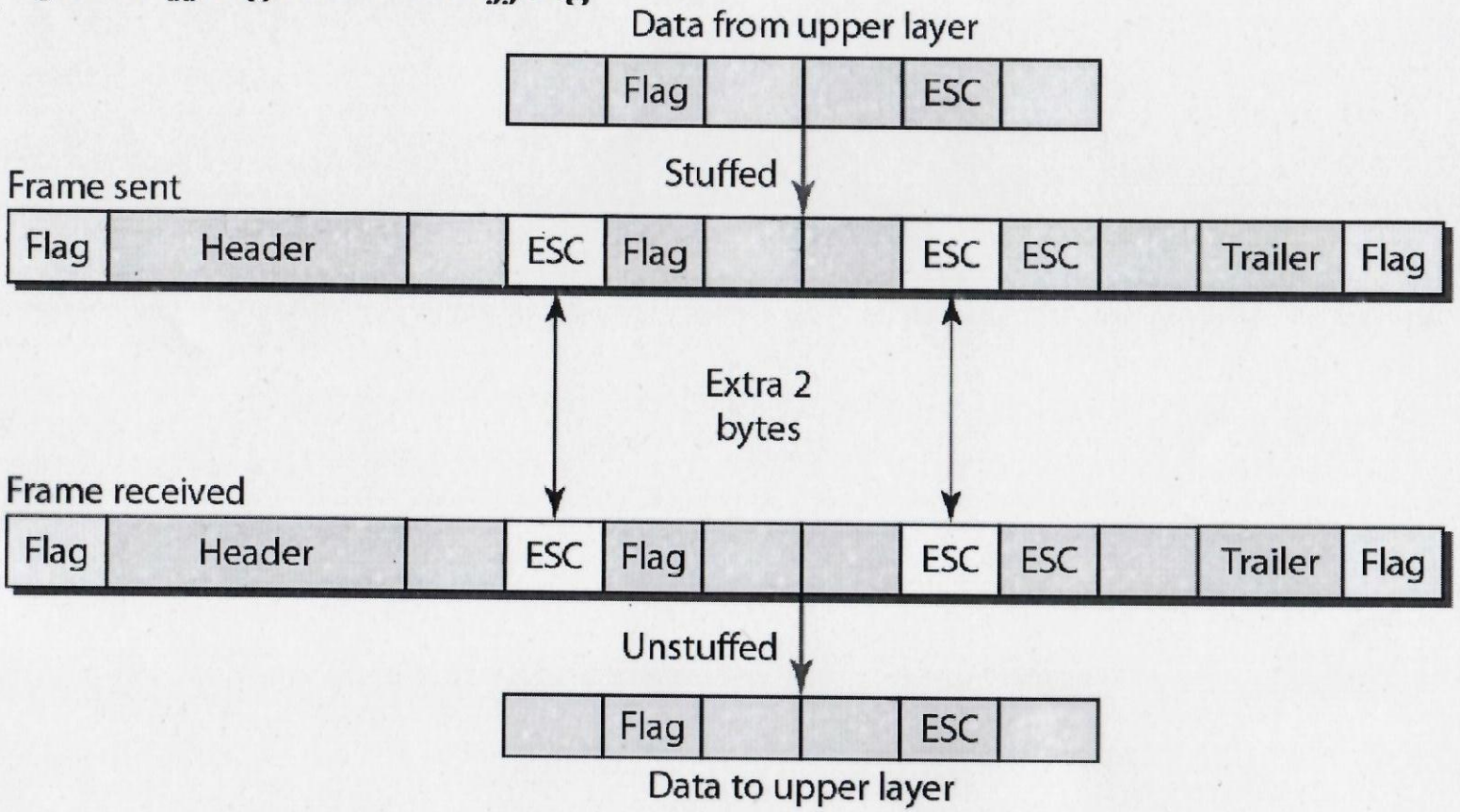
Fixed-Size Framing
Variable-Size Framing

A frame in a character-oriented protocol



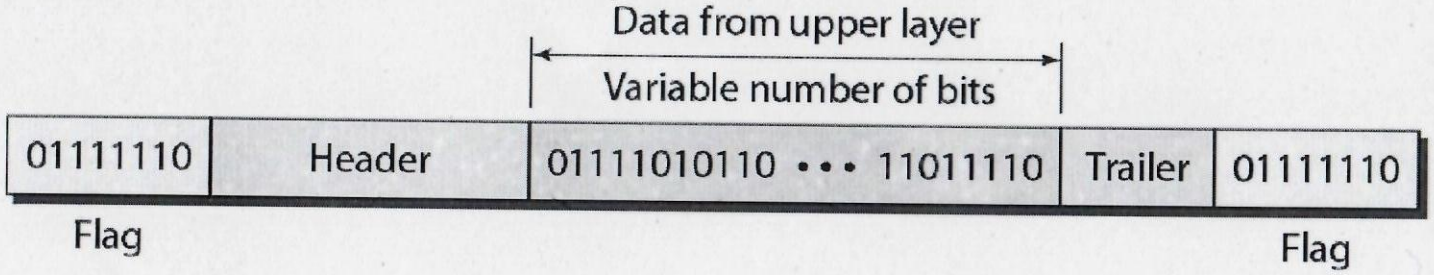
Flag (1 byte) is composed of special characters based on protocol used. Trailer contains redundant bits in multiples of 8 for error detection and correction.

Byte stuffing and unstuffing



Byte stuffing is the process of adding 1 extra byte whenever there is a flag or escape character in the text.

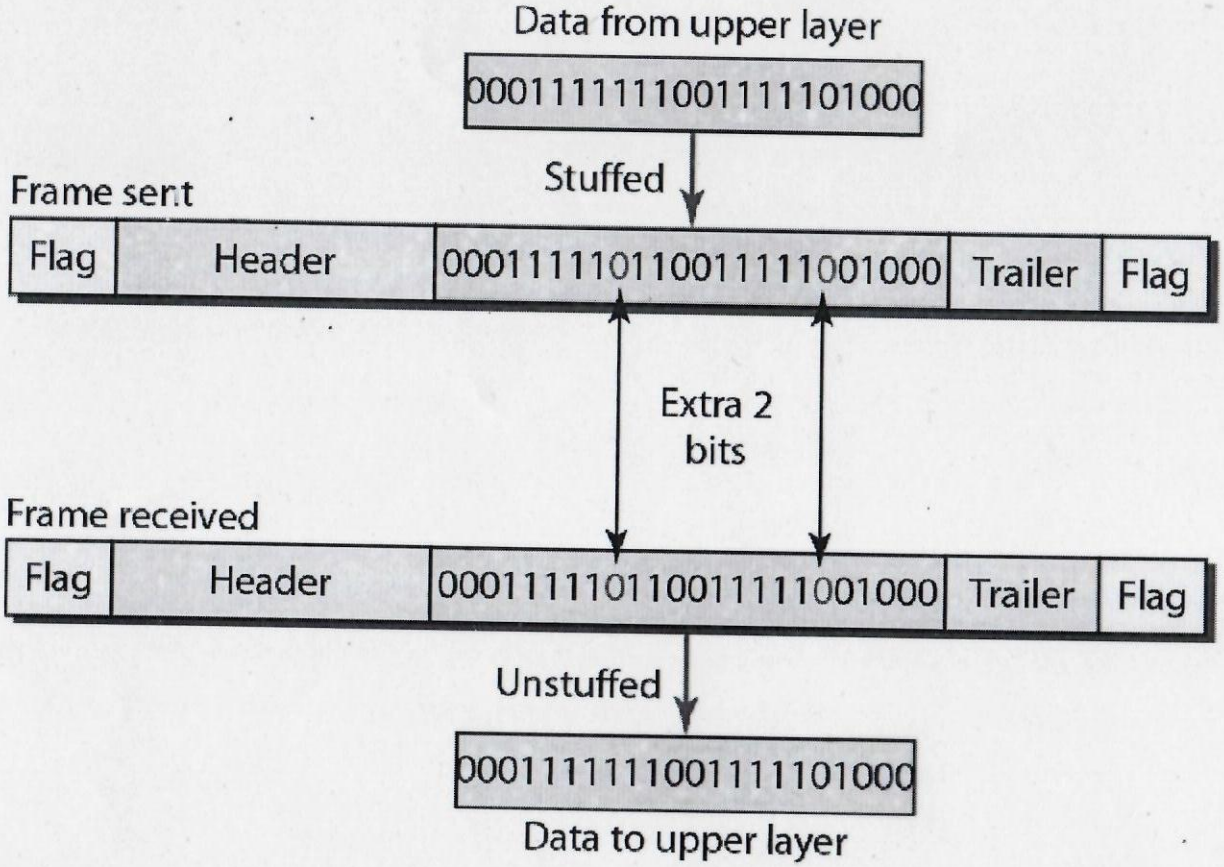
A frame in a bit-oriented protocol



Most protocols use 01111110 as Flag.

Bit stuffing is the process of adding one extra 0 whenever five consecutive 1s follow a 0 in the data, so that the receiver does not mistake the pattern 0111110 for a flag.

Bit stuffing and unstuffing



FLOW & ERROR CONTROL

FLOW CONTROL is a set of procedures that tells sender how much data it can transmit before waiting for an ACK. Receiver has buffers to hold incoming data.

ERROR CONTROL is both error detection & correction. Allows receiver to inform sender of any frames that are lost or damaged in transmission & coordinates retransmission of those frames by sender.

Error control in data link layer refers to error detection & retransmission. If error occurs, specific frames are retransmitted. This is called Automatic Repeat Request (ARQ).

PROTOCOLS

For Noiseless Channel

1. Simplest
2. Stop & Wait

For Noisy Channel

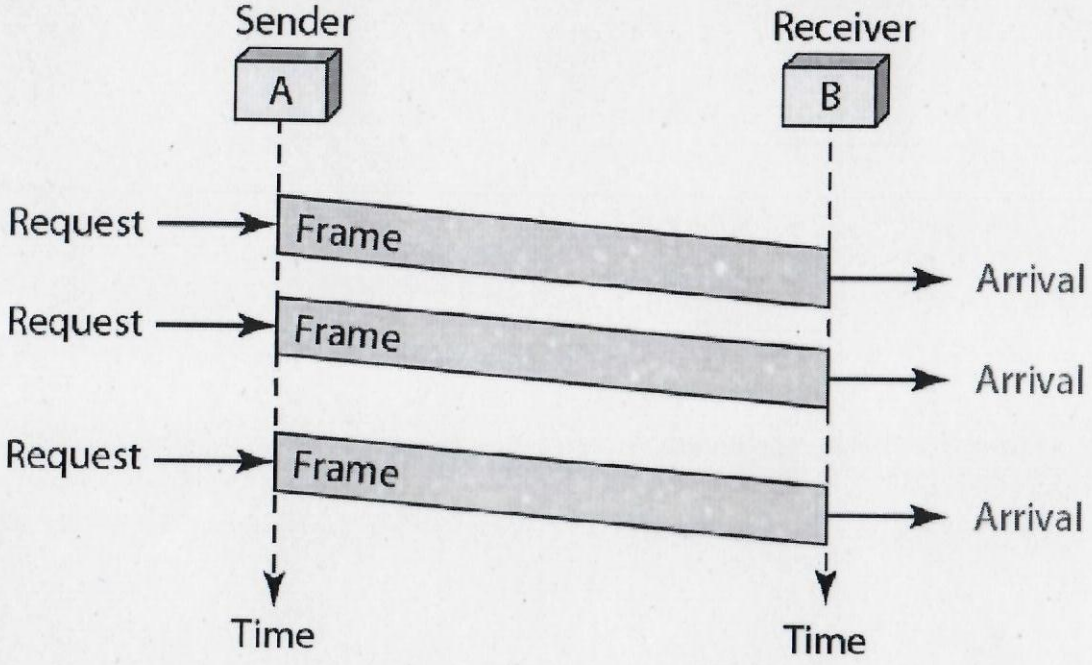
1. Stop & wait ARQ
2. Go-Back-N ARQ
3. Selective Repeat ARQ

Simplest: No flow or error control.

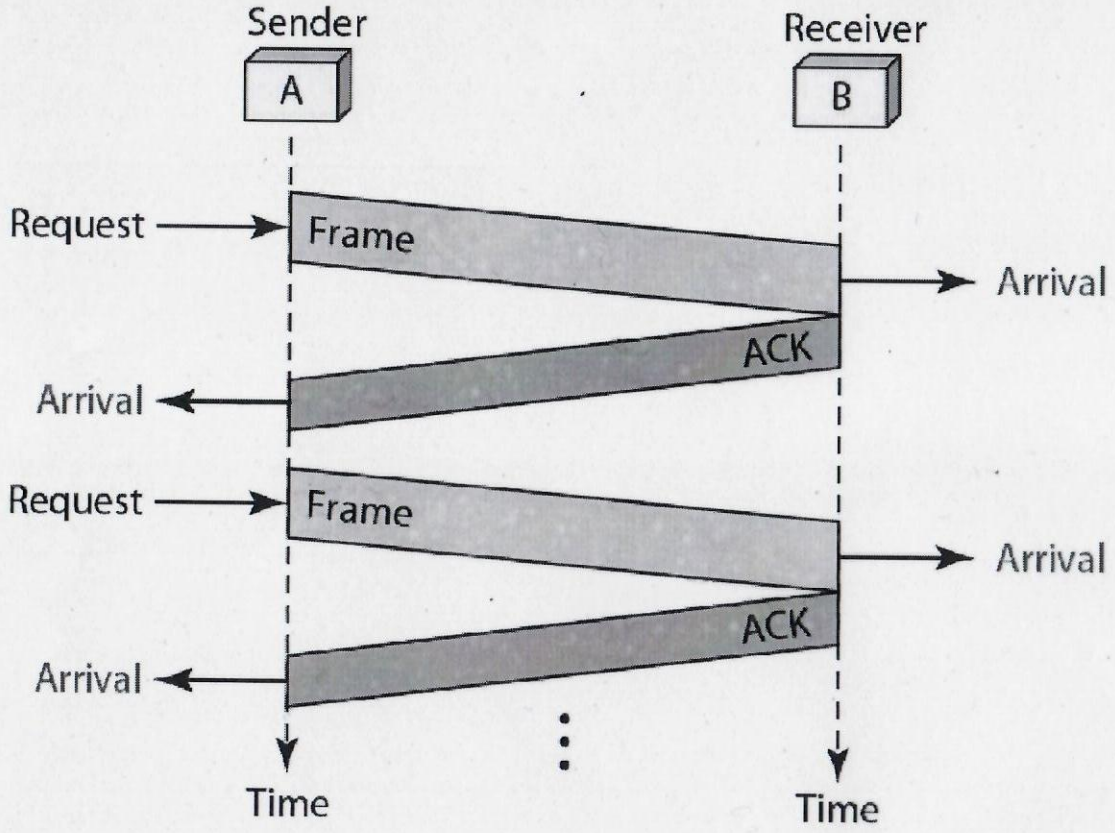
Stop & Wait: sender sends one frame, stops until it receives confirmation from the receiver & then send the next frame. Flow control is there.

Stop & Wait ARQ Adds error control to Stop & wait protocol.

Flow Diagram for Simplest Protocol



Flow Diagram for Stop and Wait Protocol



NOISY CHANNELS

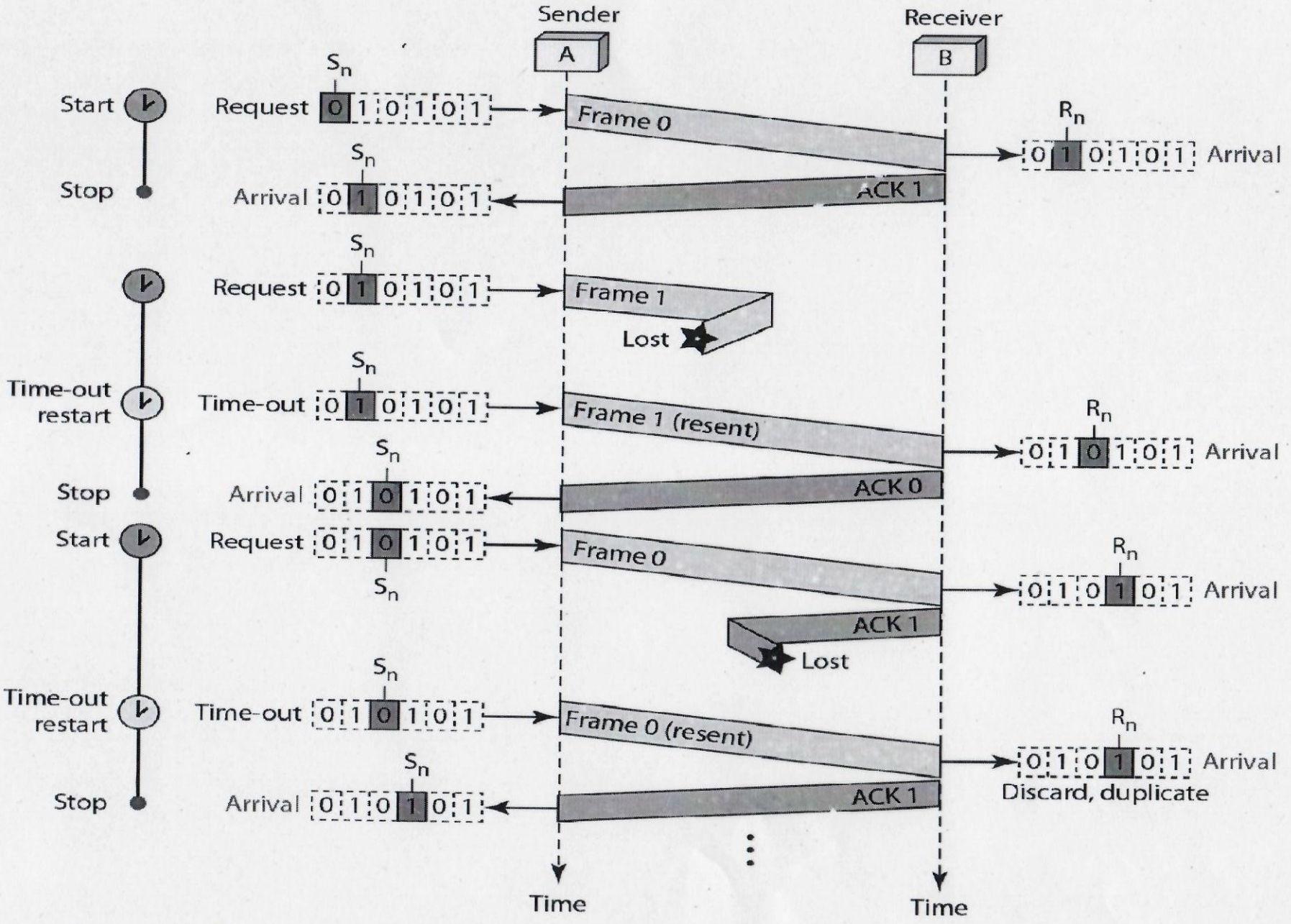
Although the Stop-and-Wait Protocol gives us an idea of how to add flow control to its predecessor, noiseless channels are nonexistent. Three protocols that use error control are :-

Stop-and-Wait Automatic Repeat Request
Go-Back-N Automatic Repeat Request
Selective Repeat Automatic Repeat Request

Error correction in Stop-and-Wait ARQ is done by keeping a copy of the sent frame and retransmitting of the frame when the timer expires.

In Stop-and-Wait ARQ, we use sequence numbers to number the frames. The sequence numbers are based on modulo-2 arithmetic. The acknowledgment number is always the sequence number of the next frame expected.

Flow Diagram for Stop and Wait ARQ Protocol



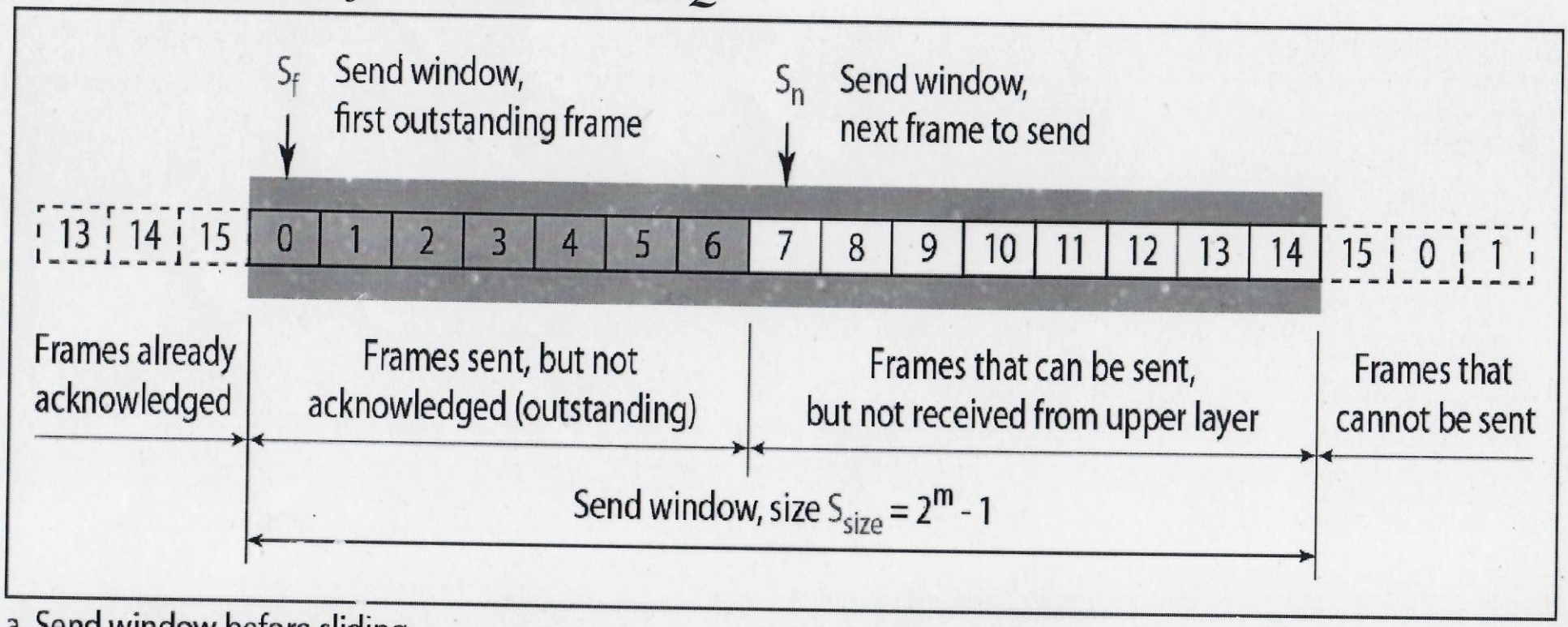
Go-Back-N Automatic Repeat Request protocol

In this protocol we send several frames and keep their copy until acknowledgement is received. Sent frames are numbered sequentially.The sequence numbers are modulo 2^m,where m is the size of the sequence number field in bits. For e.g if m=4 seq nos are from 0 to 15. We can repeat the sequence nos.

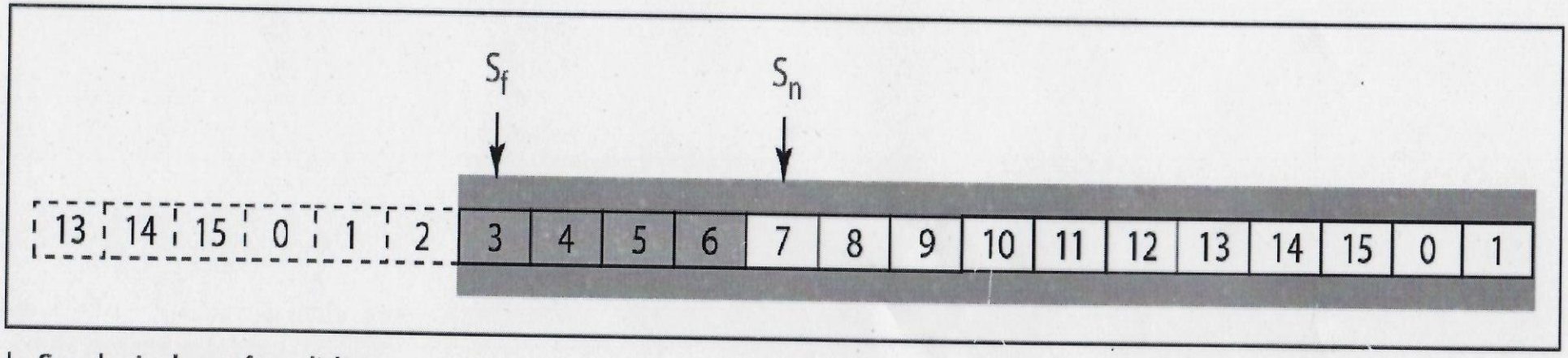
Sliding Window

In this protocol sliding window is an abstract concept that defines seq nos for sender and receiver. Max size of window is 2^m-1. Figure below shows sliding window of size 15. Window has four parts.

Send window for Go-Back-N ARQ



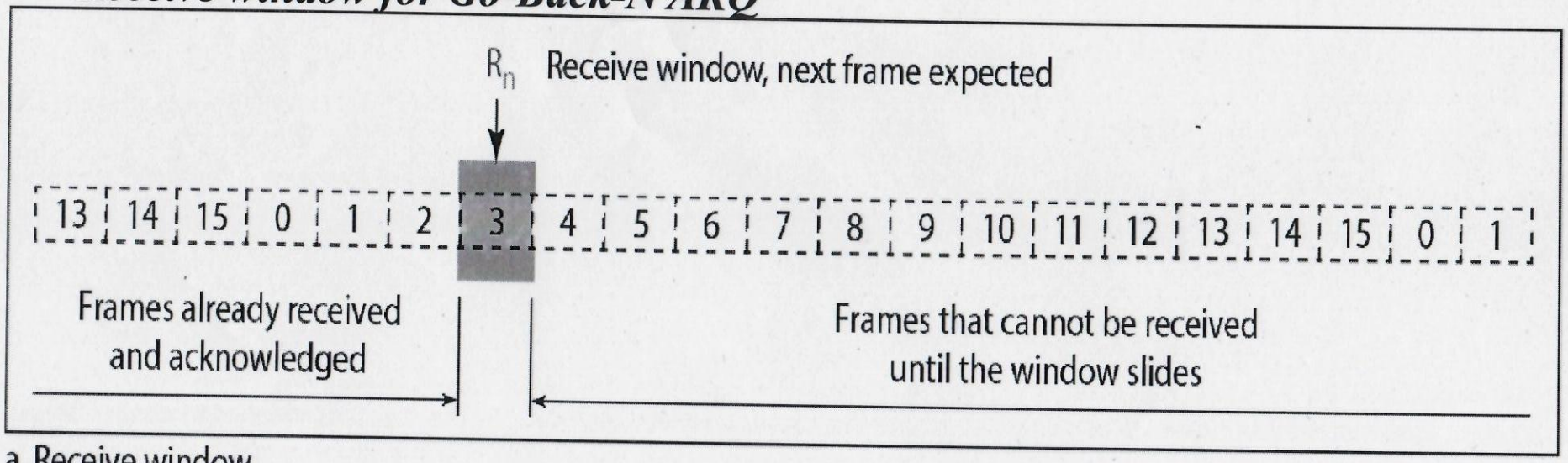
a. Send window before sliding



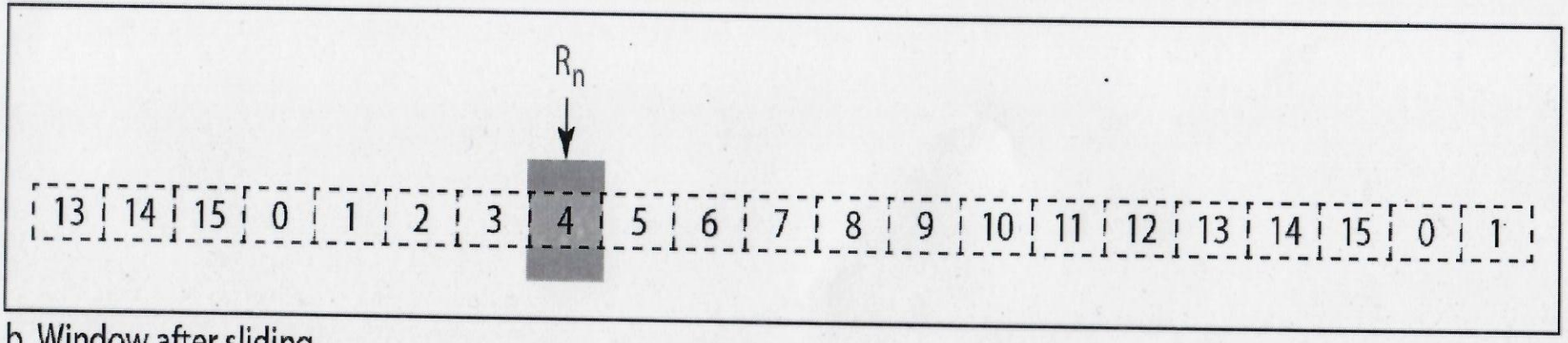
b. Send window after sliding

The send window is an abstract concept defining an imaginary box of size $2^m - 1$ with three variables: S_f, S_n, and S_{size}. The send window can slide one or more slots when a valid acknowledgment arrives.

Receive window for Go-Back-N ARQ



a. Receive window



b. Window after sliding

The receive window is an abstract concept defining an imaginary box of size 1 with one single variable R_n. The window slides when a correct frame has arrived; sliding occurs one slot at a time

This protocol uses one timer because timer for first outstanding frame always expires first; we send all outstanding frames when this timer expires.

The receiver sends positive acknowledgement if a frame has arrived safe and sound and in order. If a frame is damaged or is received out of order, the receiver is silent and will discard all subsequent frames until it receives the one it is expecting. The silence of the receiver causes the timer of the unacknowledged frame at the sender site to expire. This causes sender to send all frames beginning with the one with expired timer. Receiver sends cumulative acknowledgement.

When the timer expires the sender resends all outstanding frames. For e.g suppose the sender has already sent frame 6, but timer for frame 3 expires. This means that frame 3 has not been acknowledged;the sender goes back and sends frames 3,4,5and 6 again. That is why protocol is called Go-Back-N-ARQ.

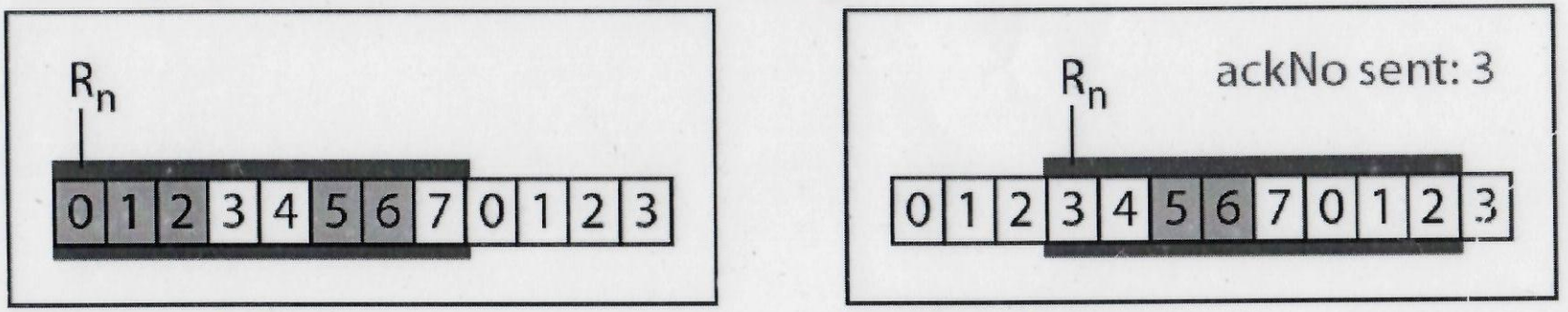
Stop-and-Wait ARQ is a special case of Go-Back-N ARQ in which the size of the send window is 1.

Selective Repeat Automatic Repeat Request

For noisy links, N frames are not sent but only damaged frames are resent in Selective Repeat ARQ protocol. It is more efficient for noisy links, but processing at the receiver is more complex.

The receive and send windows has max size of 2^m-1 and they are of equal size. Fore.g if m=4, the seq nos can be from 0 to 15, but size of window is 8 (it is 15 in Go-Back-N- Protocol)

Delivery of data in Selective Repeat ARQ



a. Before delivery

b. After delivery