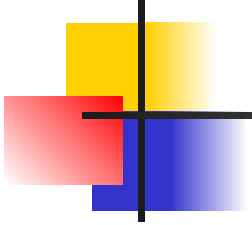


Data Link Control and Protocols

Flow and Error Control

The most important responsibilities of the data link layer are flow control and error control. these functions are known as :

data link control.

Data link control.

- *Data must be checked and processed before they can be used.*
- *The rate of such processing is often slower than the rate of transmission.*
- *For this reason , each receiver has a buffer to store incoming data until they are processed.*
- *If buffer begin to fill up, the sender must slow or halt transmission.*

Note

Flow control refers to a set of procedures used to restrict the amount of data that the sender can send before waiting for acknowledgment.

Data link control.

Error control : is both error detection and correction. Error correction in data link layer is implemented simply: anytime an error is detected in exchange, specified frames are retransmitted. This process is called Automatic Repeat Request

Note

Error control in the data link layer is based on automatic repeat request, which is the retransmission of data.

PROTOCOLS

Now let us see how the data link layer can combine flow control , and error control to achieve the delivery of data from one node to another . The protocols are normally implemented in software by using one of the common programming languages.

PROTOCOLS

- *Stop-and-Wait ARQ*
- *Go-Back-N ARQ*
- *Selective Repeat ARQ*

Stop-and-Wait ARQ

- *It is the simplest flow and error control mechanism . A transmitter sends a frame then stops and waits for an acknowledgment.*
- *Stop-and-Wait ARQ has the following features:*

✔ *The sending device keeps a copy of the sent frame transmitted until it receives an acknowledgment(ACK)*

✔ *The sender starts a timer when it sends a frame. If an ACK is not received within an allocated time period, the sender resends it*

✔ *Both frames and acknowledgment (ACK) are numbered alternately 0 and 1(two sequence number only)*

✔ *This numbering allows for identification of*

Stop-and-Wait ARQ

- *The acknowledgment number defines the number of next expected frame. (frame 0 received ACK 1 is sent)*
- *A damage or lost frame treated by the same manner by the receiver*
- *If the receiver detects an error in the received frame, or receives a frame out of order it simply discards the frame*
- *The receiver send only positive ACK for frames received safe; it is silent about the frames damage or lost.*
- *The sender has a control variable Sthat holds the number of most recently sent frame (0 or 1). The receiver has control variable R, that holds*

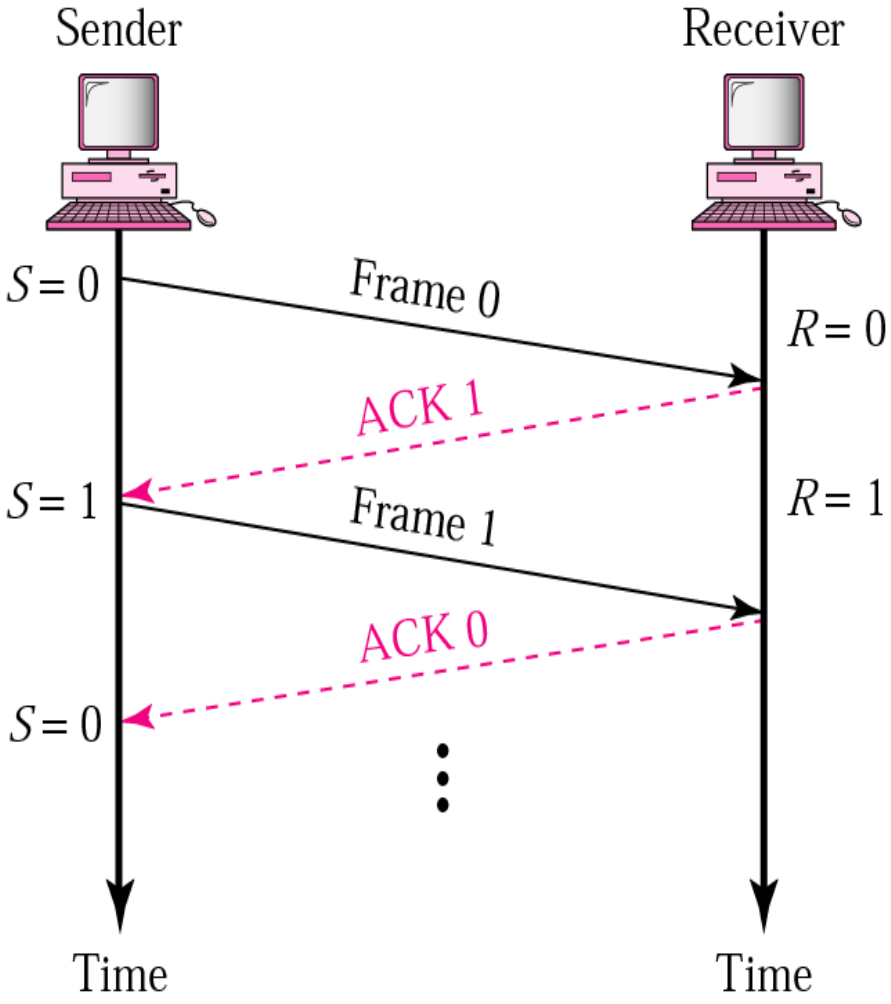
Stop-and-Wait ARQ

Cases of Operations:

1. *Normal operation*
2. *The frame is lost*
3. *The Acknowledgment (ACK) is lost*
4. *The Ack is delayed*

Stop-and-Wait ARQ Normal operation

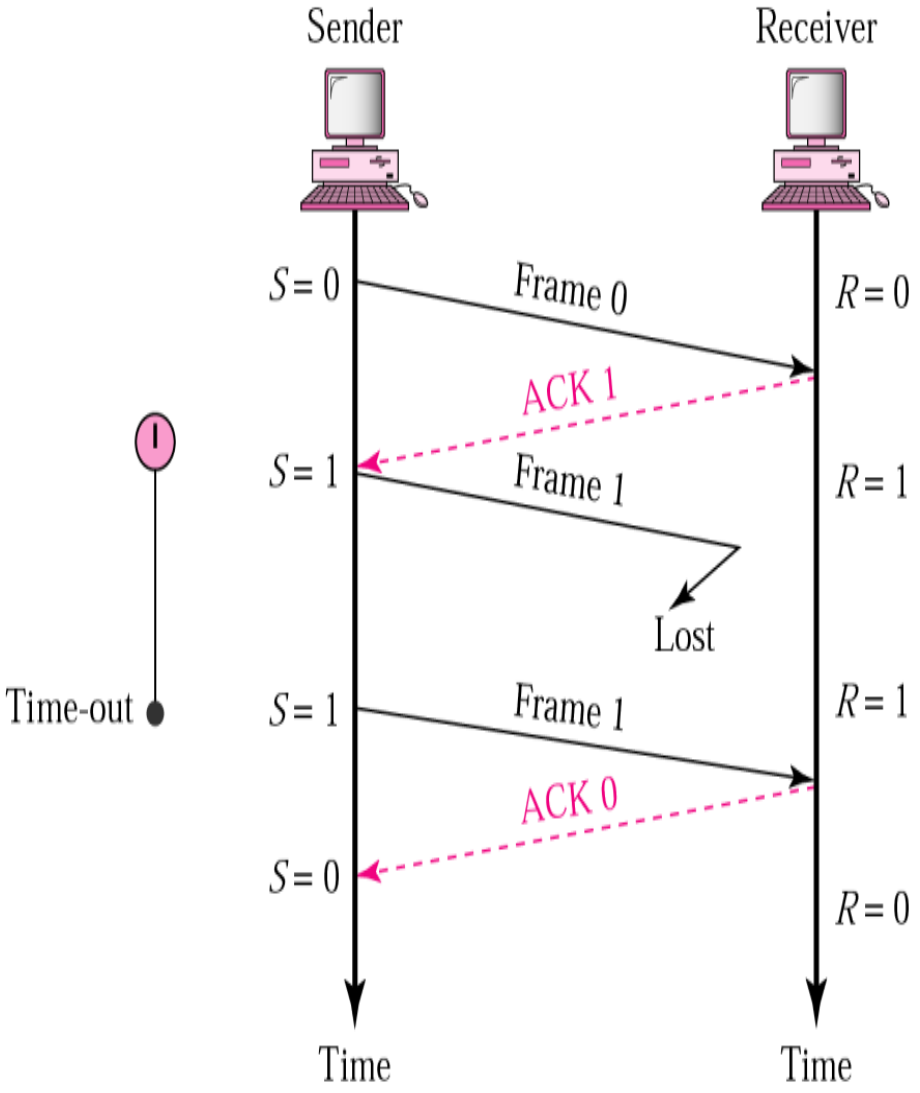
- *The sender will not send the next frame until it is sure that the current one is correctly receive.*
- *sequence number is necessary to check for duplicated frames.*



1. Stop and Wait ARQ

2. Lost or damaged frame

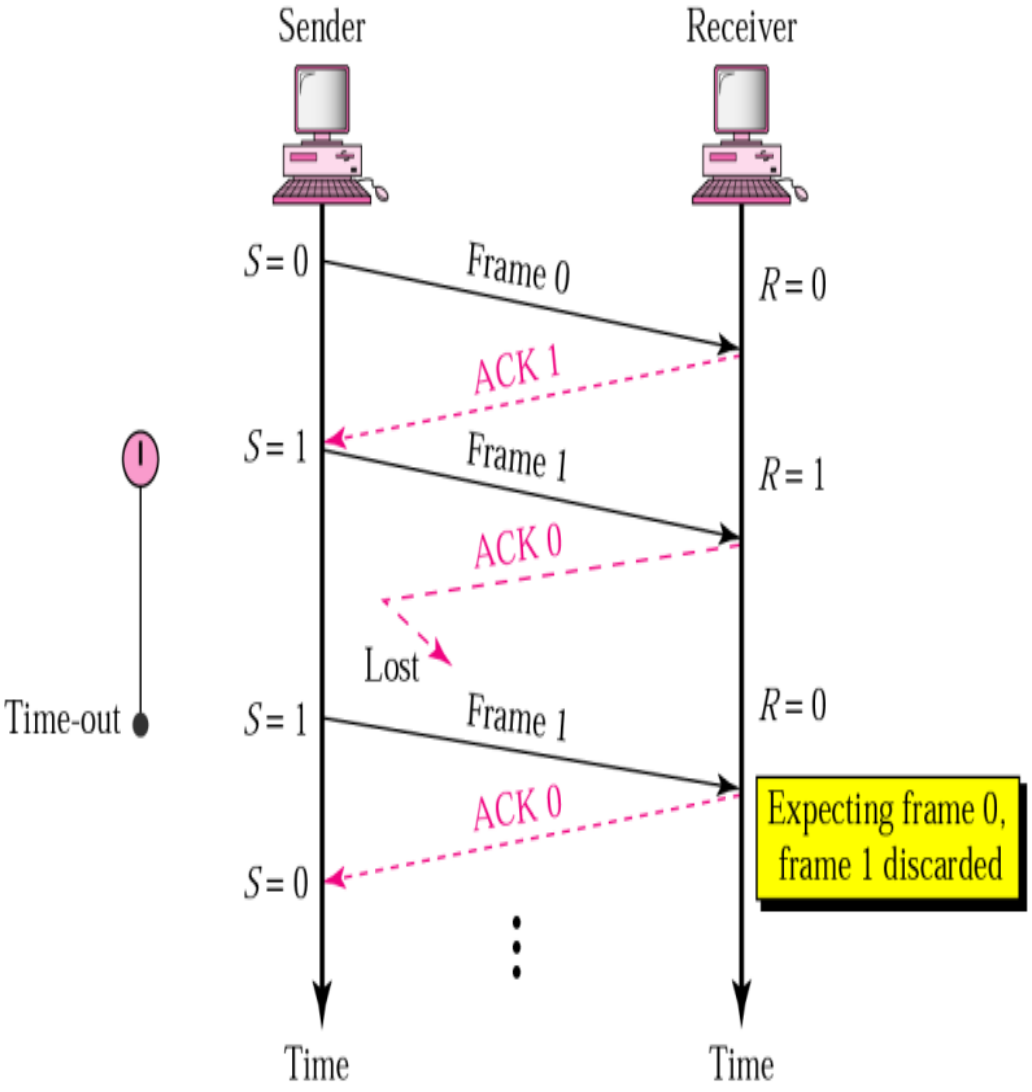
- *A damage or lost frame treated by the same manner by the receiver.*
- *No NACK when frame is corrupted / duplicate*



Stop-and-Wait ARQ

3. Lost ACK frame

- *Importance of frame numbering*



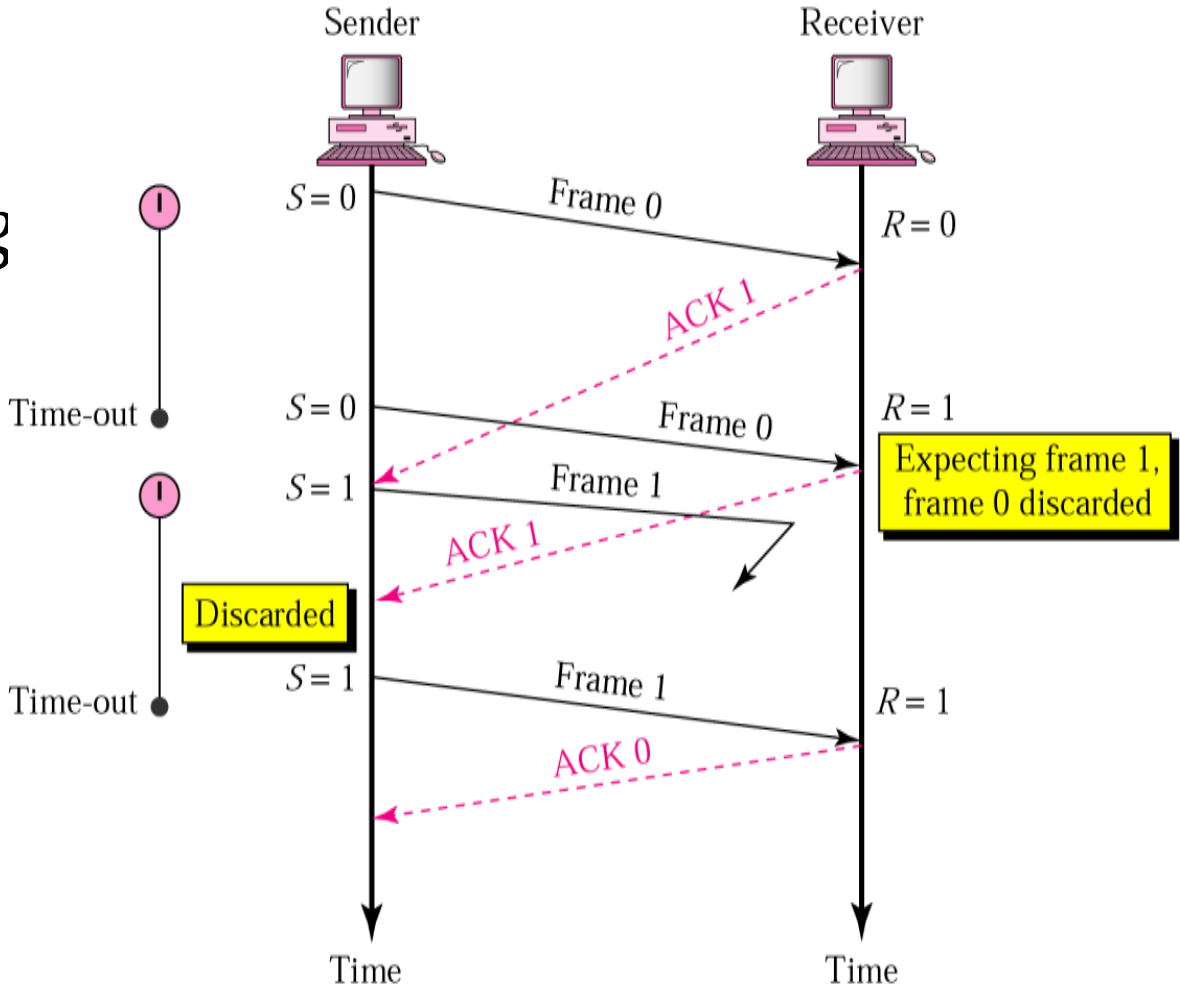
Note

In Stop and-Wait ARQ, numbering frames prevents the retaining of duplicate frames.

Stop-and-Wait ARQ

4. Delayed ACK and lost frame

- *Importance of frame numbering*



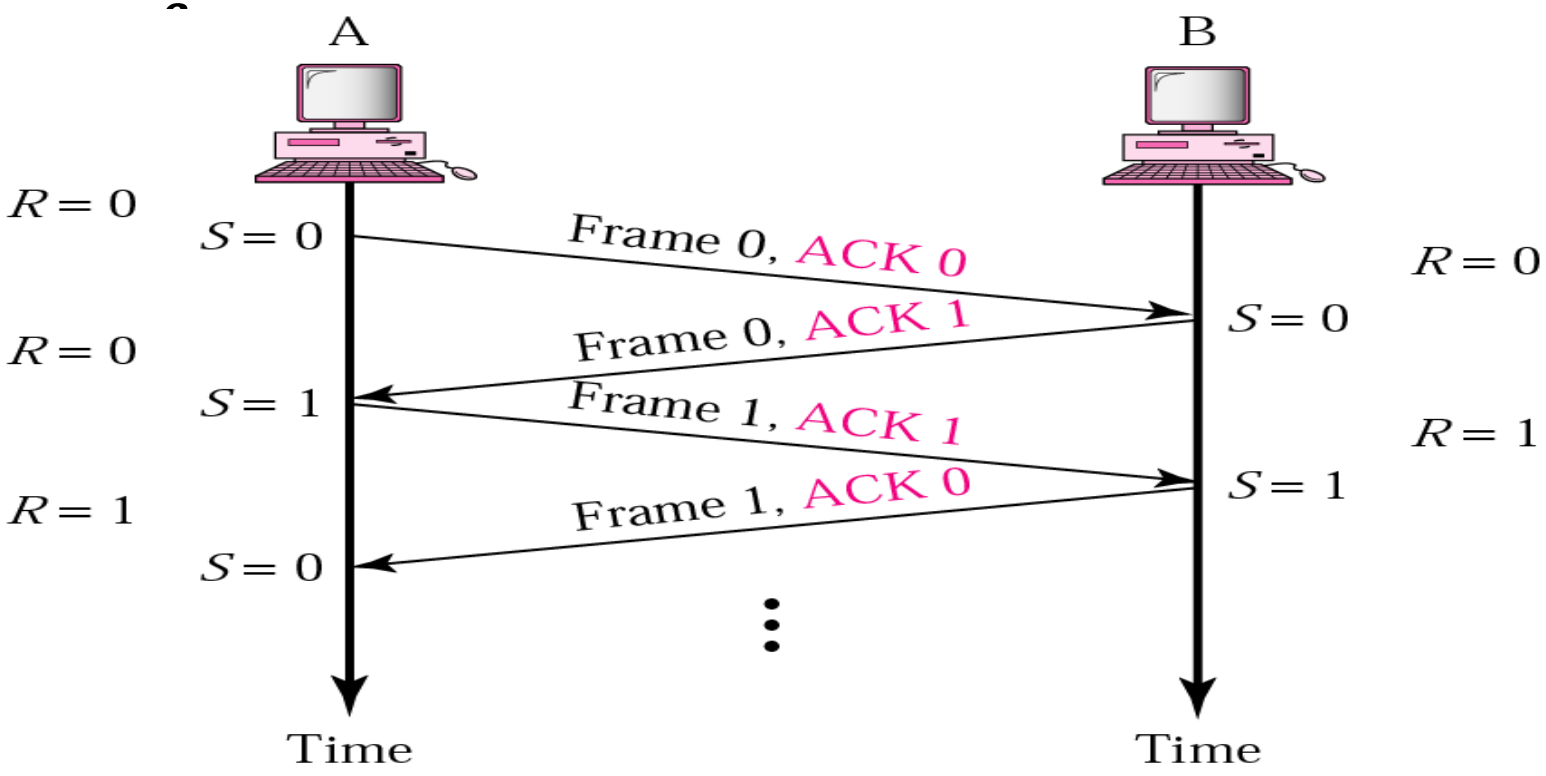
Note

Numbered acknowledgments are needed if an acknowledgment is delayed and the next frame is lost.

Piggybacking (Bidirectional transmission)

Is a method to combine a data frame with an acknowledgment.

It can save bandwidth because data frame and an ACK frame can combined into just



Stop-and-Wait ARQ

After each frame sent the host must wait for an ACK

- *inefficient use of bandwidth*

To improve efficiency ACK should be sent after multiple frames

Alternatives: Sliding Window protocol

- ✔ *Go-back-N ARQ*
- ✔ *Selective Repeat ARQ*

Sliding window protocol

Sliding window protocols apply Pipelining :

- ✔ *Go-Back-N ARQ*
- ✔ *Selective Repeat ARQ*
- *Sliding window protocols improve the efficiency*
- *multiple frames should be in transition while waiting for ACK. Let more than one frame to be outstanding.*
- *Outstanding frames: frames sent but not acknowledged*
- *We can send up to W frames and keep a copy of these frames(outstanding) until the ACKs arrive.*
- *This procedures requires additional feature*

Sliding window

Sequence Numbers

- Sent frames are numbered sequentially
- Sequence number is stored in the header of the frame
- If the header of the frame allow m bits for the sequence number, the sequence numbers range from 0 to $(2^m - 1)$.

The sequence numbers are modulo 2^m, where m is the size of the sequence number field in bits.

If $m = 3$, sequence number range from 0 to 7(8 numbers): 0, 1, 2 , 3, 4, 5, 6, 7, 0 , 1 ,…..

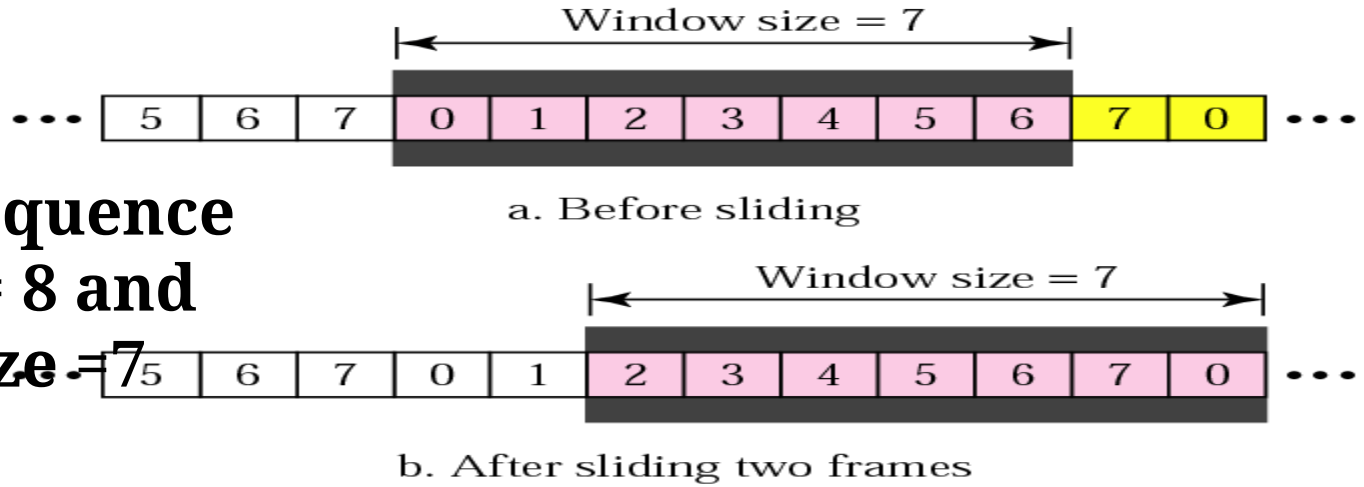
Sliding window

used to hold the unacknowledged outstanding frames (frames sent but not acknowledged)

Go_Back _N ARQ

Sender sliding window

The sender window is an abstract concept defining an imaginary box of size $2^m - 1$ *(sequence numbers –1) The sender window can slide one or more slots when a valid acknowledgment arrives.*



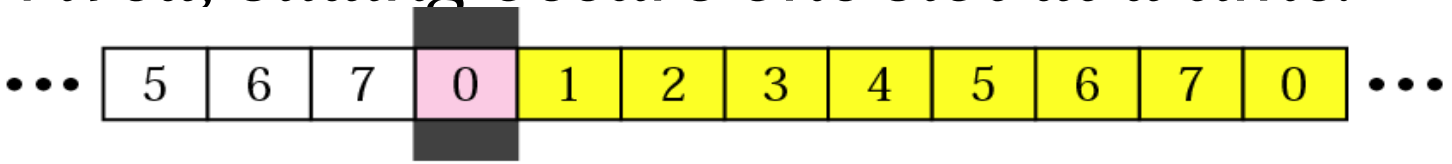
If m = 3; sequence numbers = 8 and window size = 7

Acknowledged frames

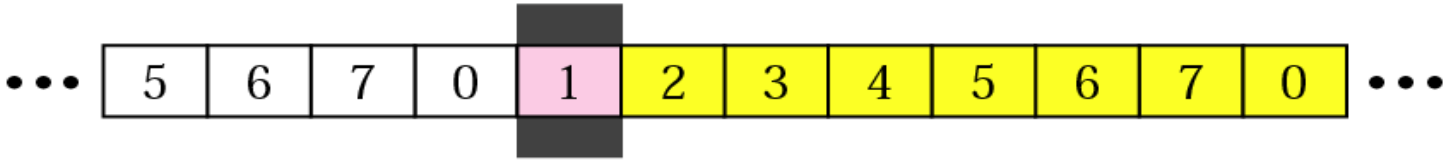
Go_Back_N ARQ

Receiver sliding window

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



a. Before sliding



b. After sliding

Note

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 ARQ

*Go-Back-N ARQ is inefficient of a **noisy** link.*

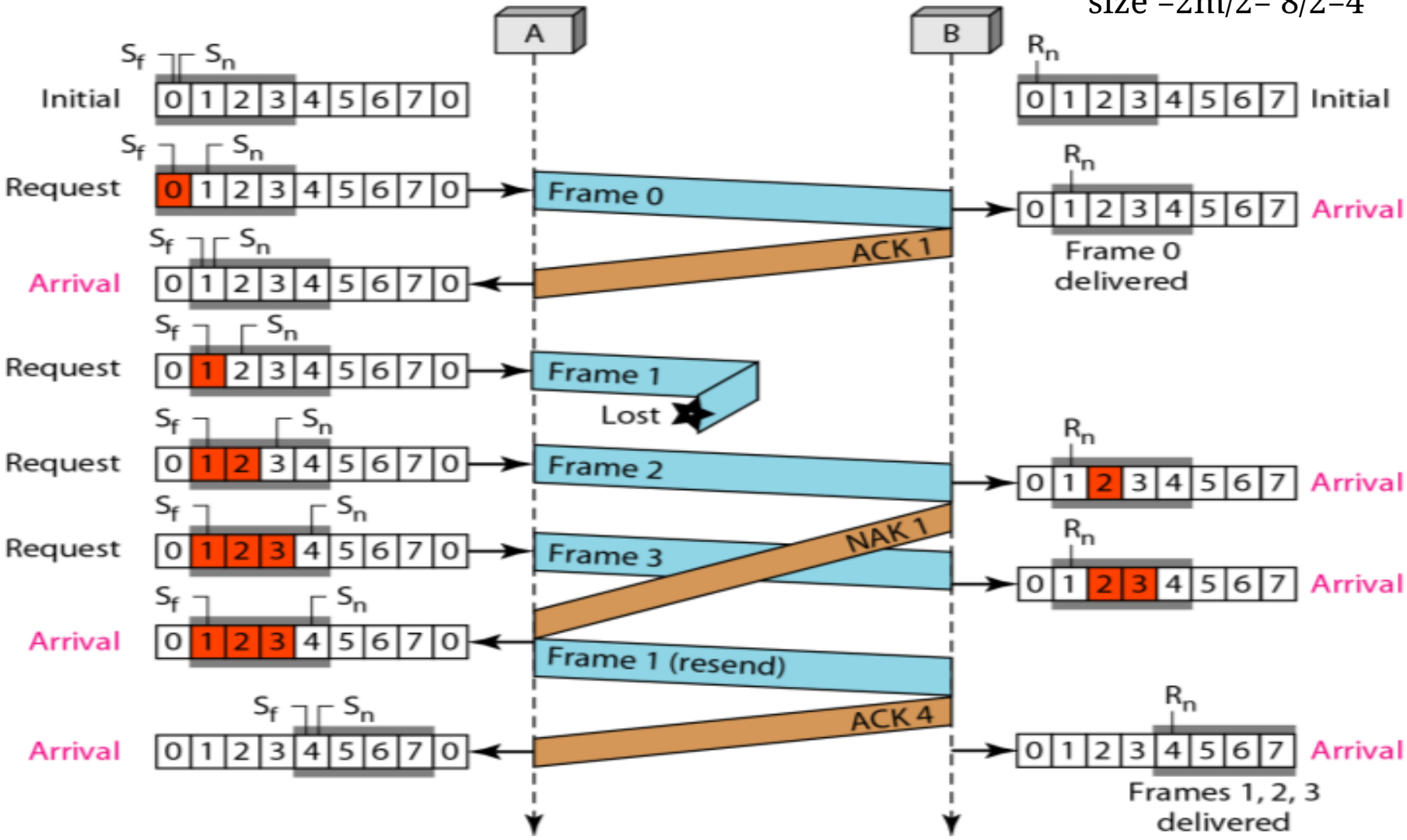
- *In a noisy link frames have higher probability of damage , which means the resending of multiple frames.*
- *this resending consumes the bandwidth and slow down the transmission .*

***Solution**:*

- *Selective Repeat ARQ protocol : resent only the damage frame.*
- *It defines a negative Acknowledge (NAK) that report the sequence number of a damaged frame before the timer expires.*
- *It is more efficient for noisy link, but the processing at*

Selective Repeat ARQ Lost Frame

m=3
Sequences no=2m
=8 : 0,1,2
,3,4,5,6,7Window
size =2m/2= 8/2=4



Selective Repeat ARQ

At the receiver site we need to distinguish between the acceptance of a frame and its delivery to the network layer .

At the second arrival , frame 2 arrives and is stored and marked , but it can not be delivered because frame 1 is missing . At the next arrival , frame 3 arrives and is marked and stored , but still none of the frames can be delivered . Only at the last arrival , when finally a copy of frame 1 arrives , can frames 1 , 2 , and 3 be delivered to the network layer. There are two conditions for the delivery of frames to the network layer: First , a set of consecutive frames must have arrived. Second, the set starts from the beginning of the window.