Chapter 11

Data Link Control

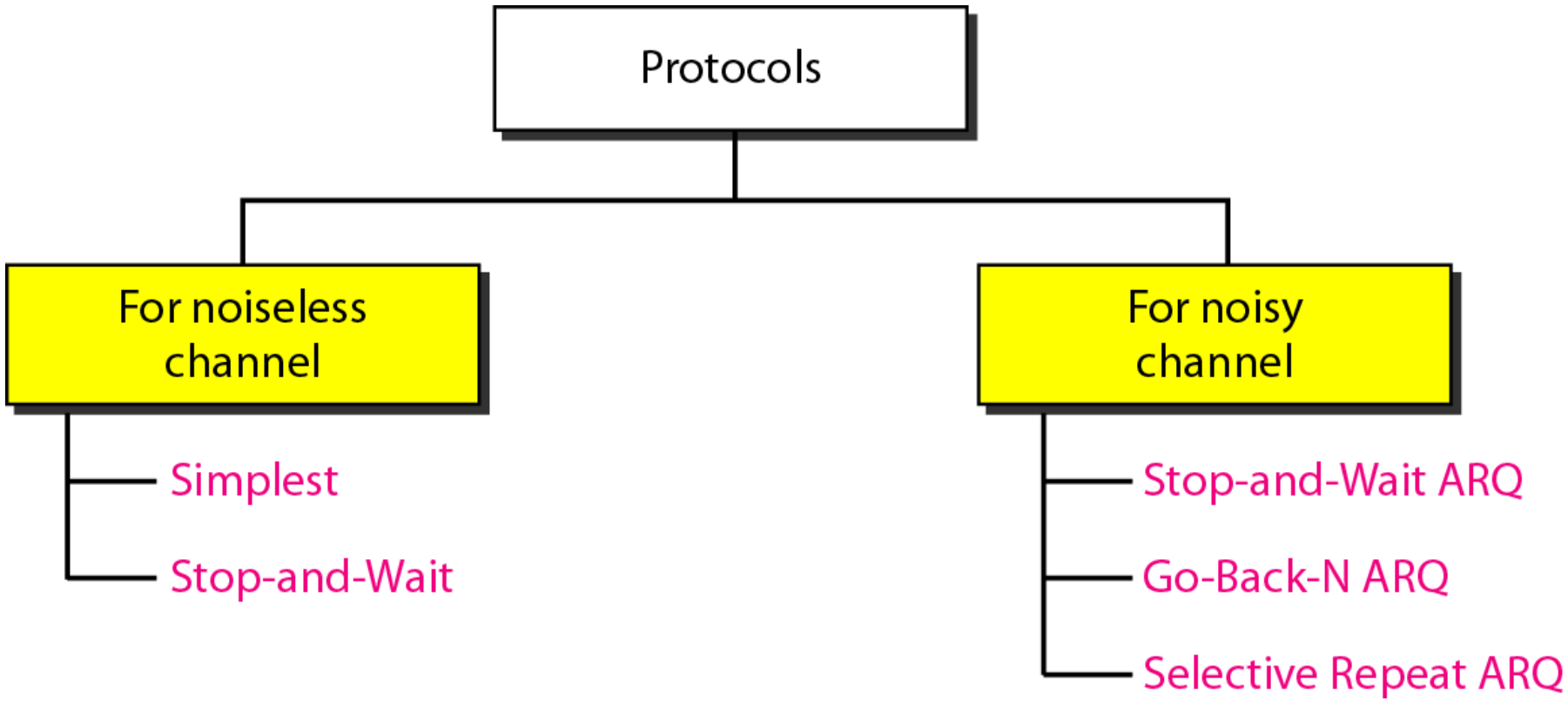
11-2 FLOW AND ERROR CONTROL

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

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

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

11-3 PROTOCOLS



11-4 NOISELESS CHANNELS

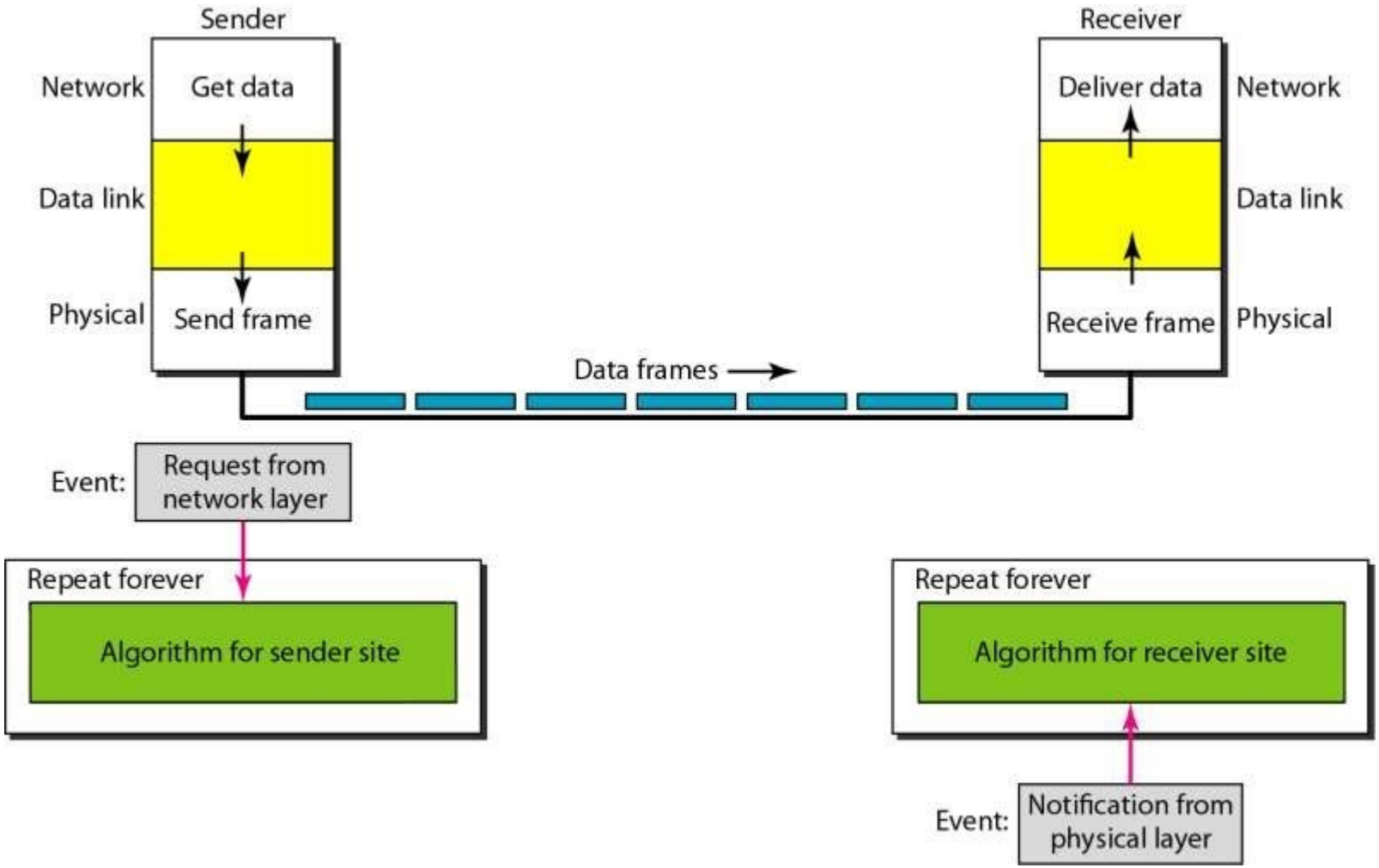
Let us first assume we have an ideal channel in which no frames are lost, duplicated, or corrupted. We introduce two protocols for this type of channel.

Topics discussed in this section:

Simplest Protocol

Stop-and-Wait Protocol

Figure 11.6 *The design of the simplest protocol with no flow or error control*



Example 11.1

Figure 11.6 shows an example of communication using this protocol. Itis very simple. The sender sends a sequence of frames without even thinking aboutthe receiver. To send three frames, three events occur at the sender site and three events at the receiver site. Note that the data frames are shown by tilted boxes; the height of the box defines the transmission time difference between the first bit and the last bit in the frame.

Figure 11.7 *Flow diagram for Example 11.1*

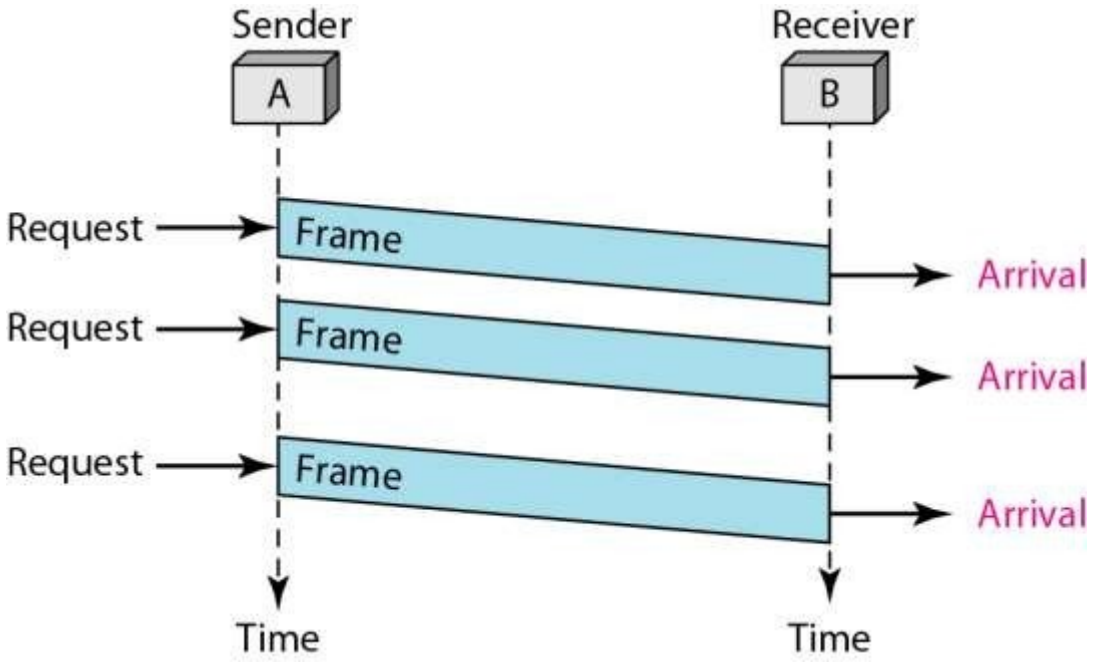
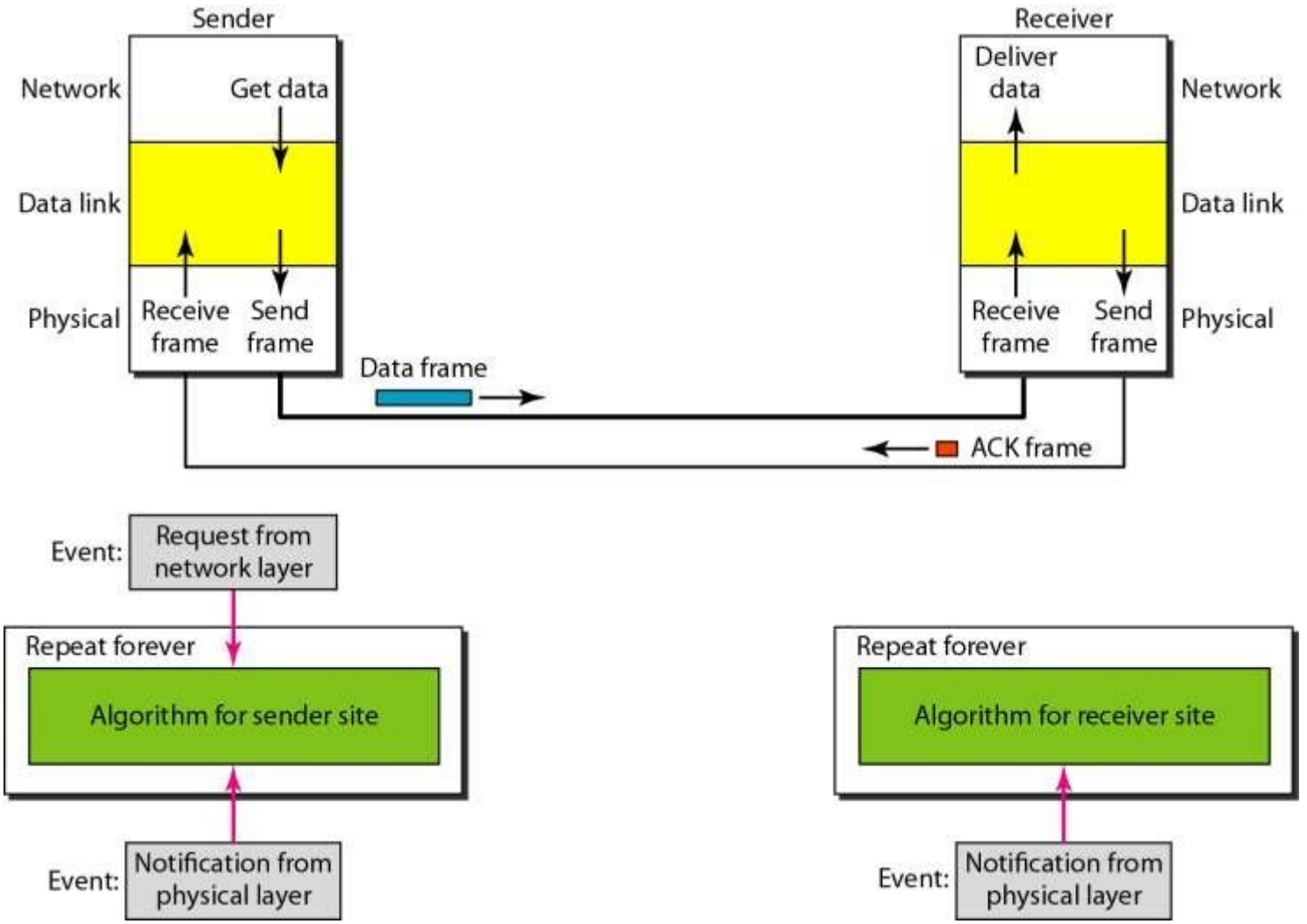


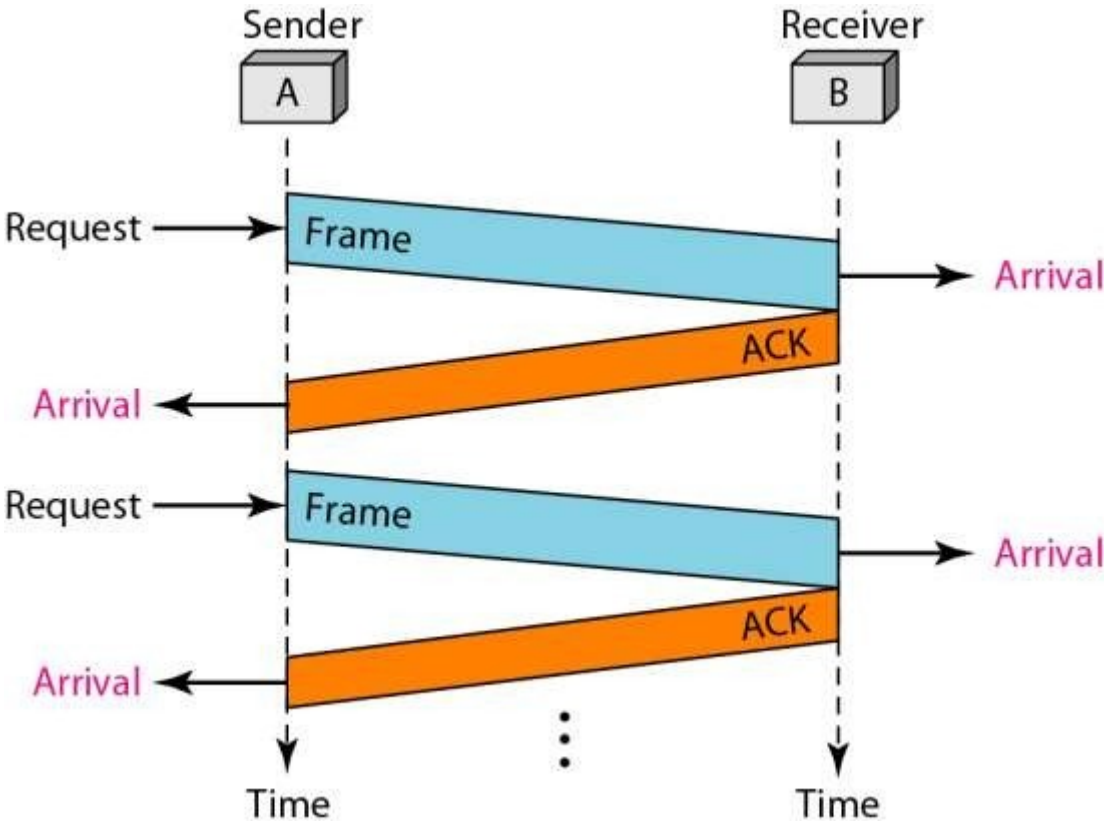
Figure 11.8 *Design of Stop-and-Wait Protocol*



Example 11.2

Figure 11.8 shows an example of communication using this protocol. It is still very simple. The sender sends one frame and waits for feedback from the receiver. When the ACK arrives, the sender sends the next frame. Note that sending two frames in the protocol involves the sender in four events and the receiver in two events.

Figure 11.9 *Flow diagram for Example 11.2*



11-5 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. We discuss three protocols in this section that use error control.

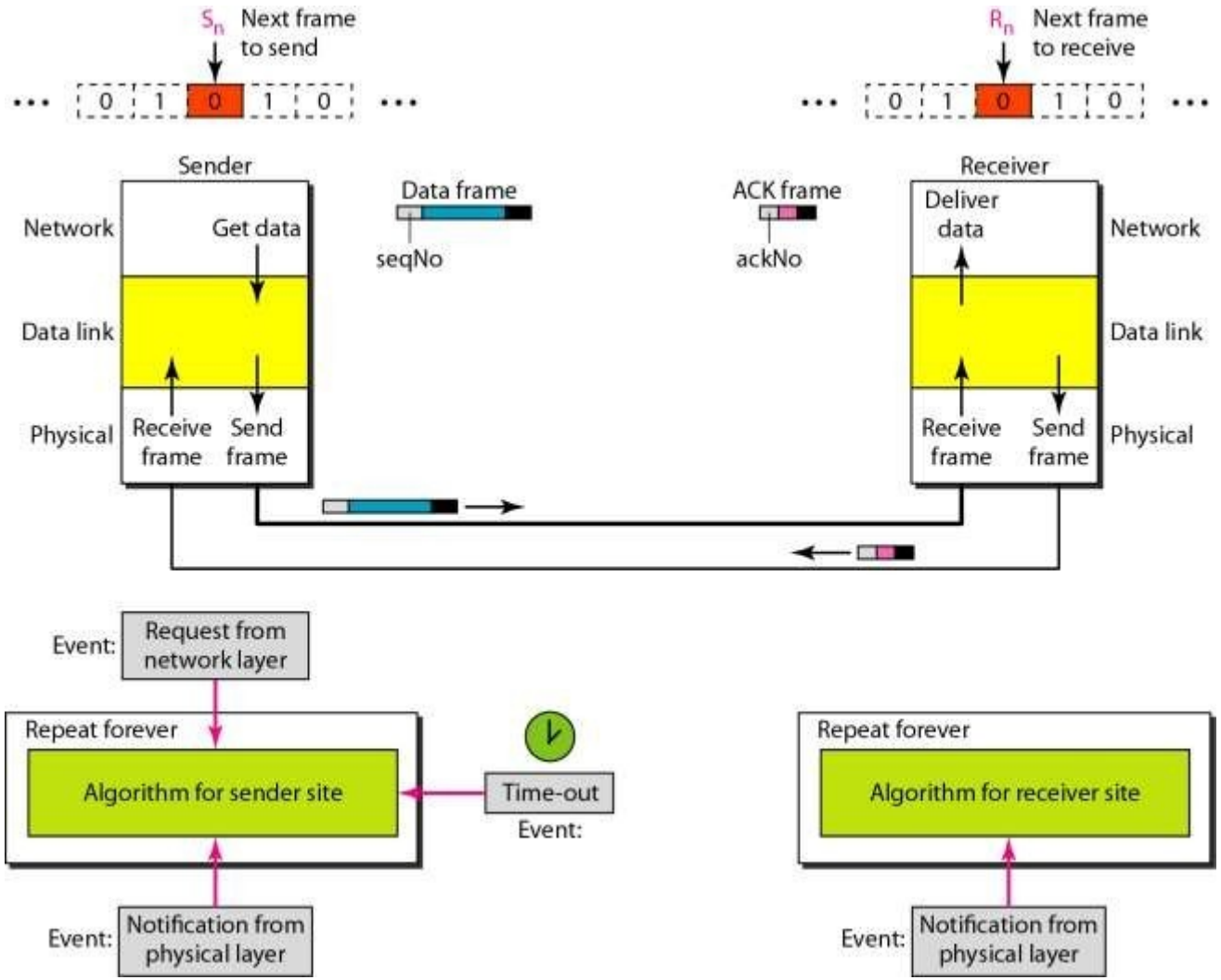
Topics discussed in this section:

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

Note

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.we use sequence numbers to number the frames. The sequence number of the next frame expected as acknowledgment number.

Figure 11.10 *Design of the Stop-and-Wait ARQ Protocol*



Example 11.3

Figure 11.10 shows an example of Stop-and-Wait ARQ. Frame 0 is sent and acknowledged. Frame 1 is lost and resent after the time-out. The resent frame 1 is acknowledged and the timer stops. Frame 0 is sent and acknowledged, but the acknowledgment is lost. The sender has no idea if the frame or the acknowledgment is lost, so after the time-out, it resends frame 0, which is acknowledged.

Figure 11.11 *Flow diagram for Example 11.3*

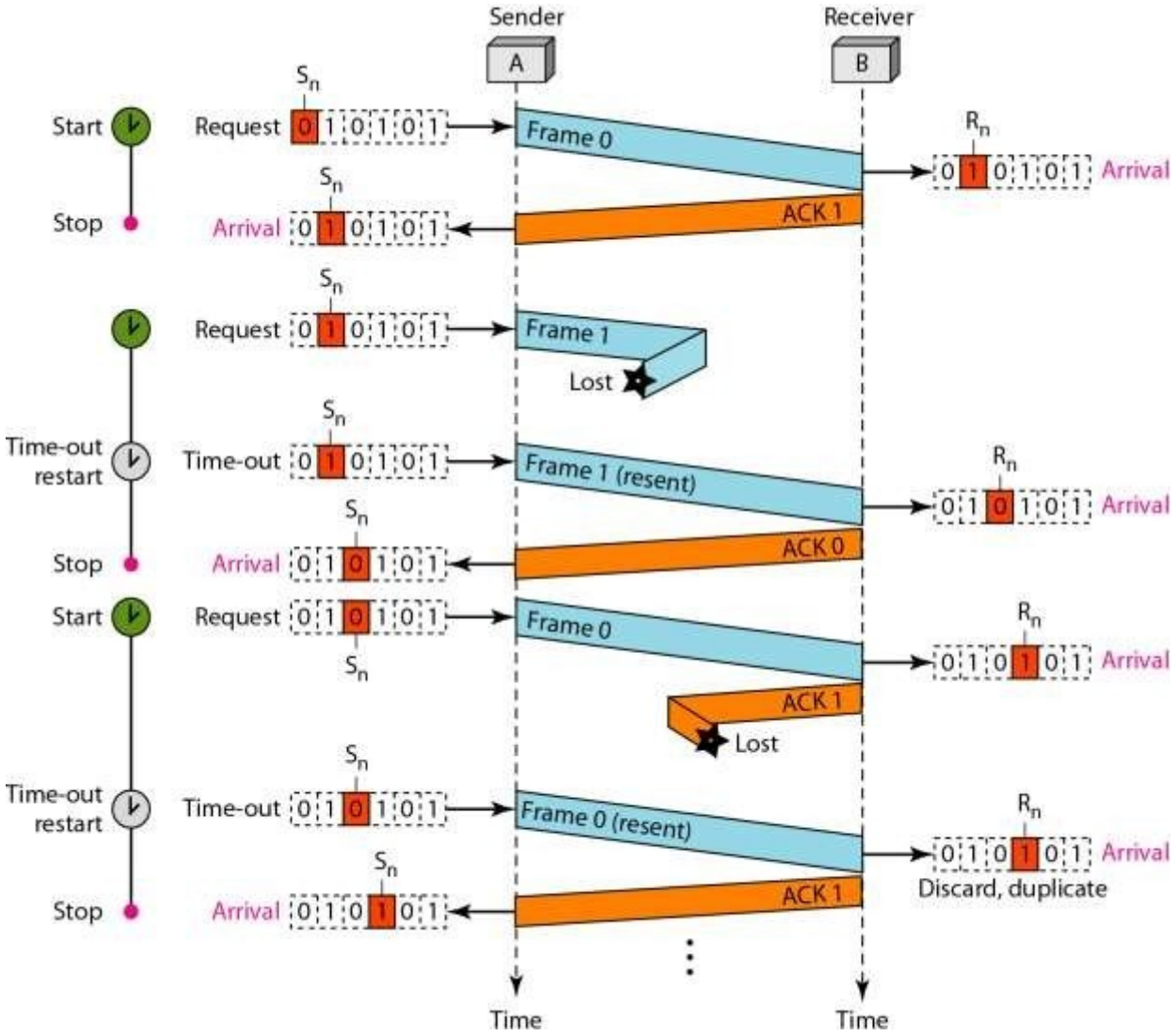
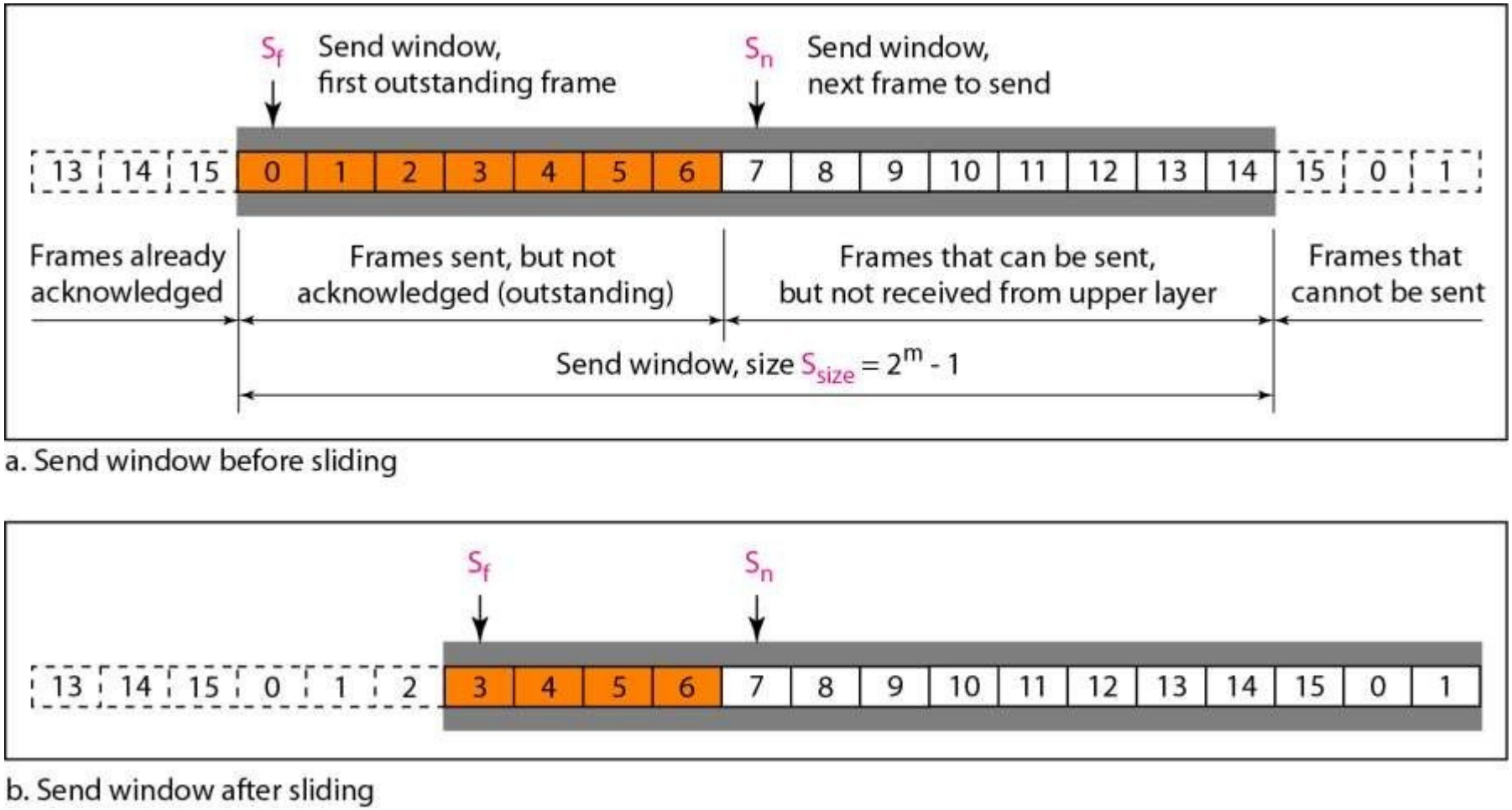


Figure 11.12 *Send window for Go-Back-N ARQ*

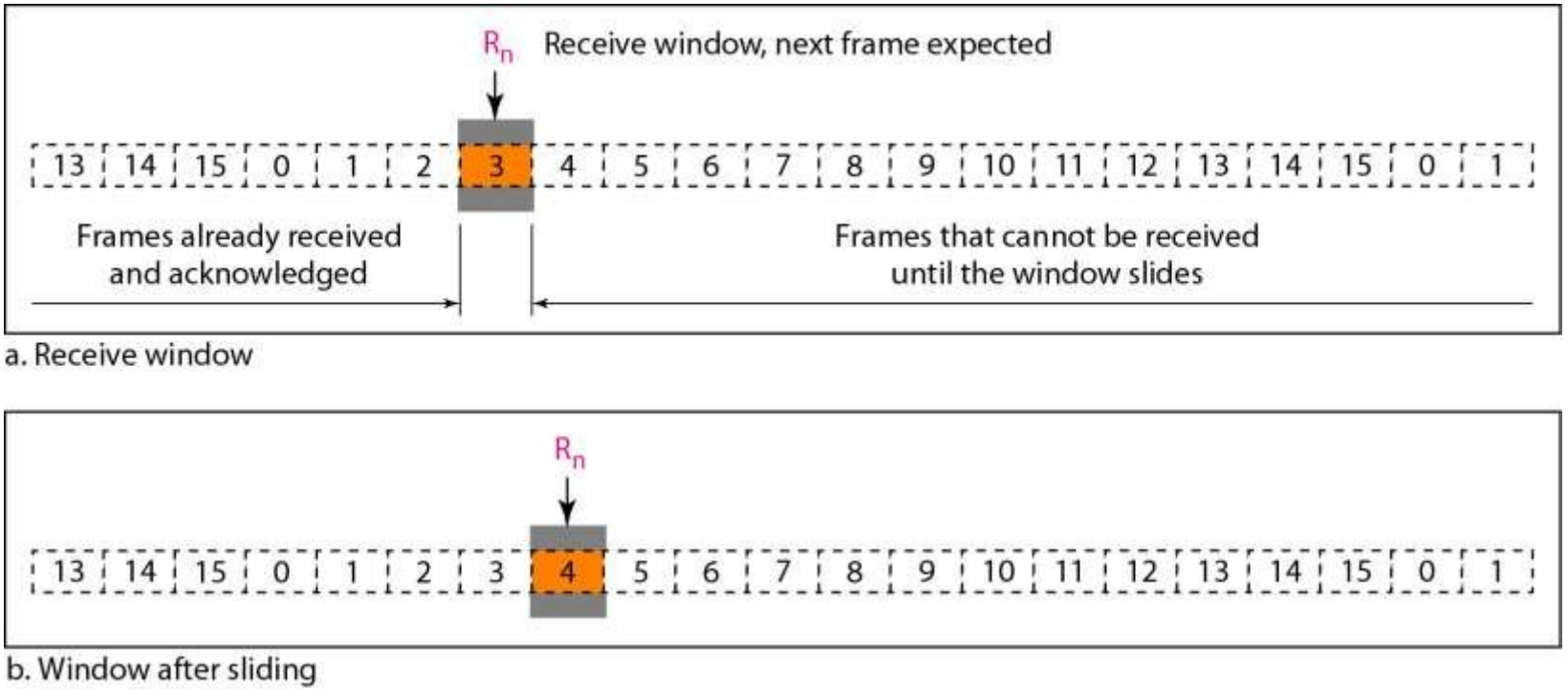


Note

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.

Figure 11.13 *Receive window for Go-Back-N ARQ*



Note

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.

Figure 11.14 *Design of Go-Back-N ARQ*

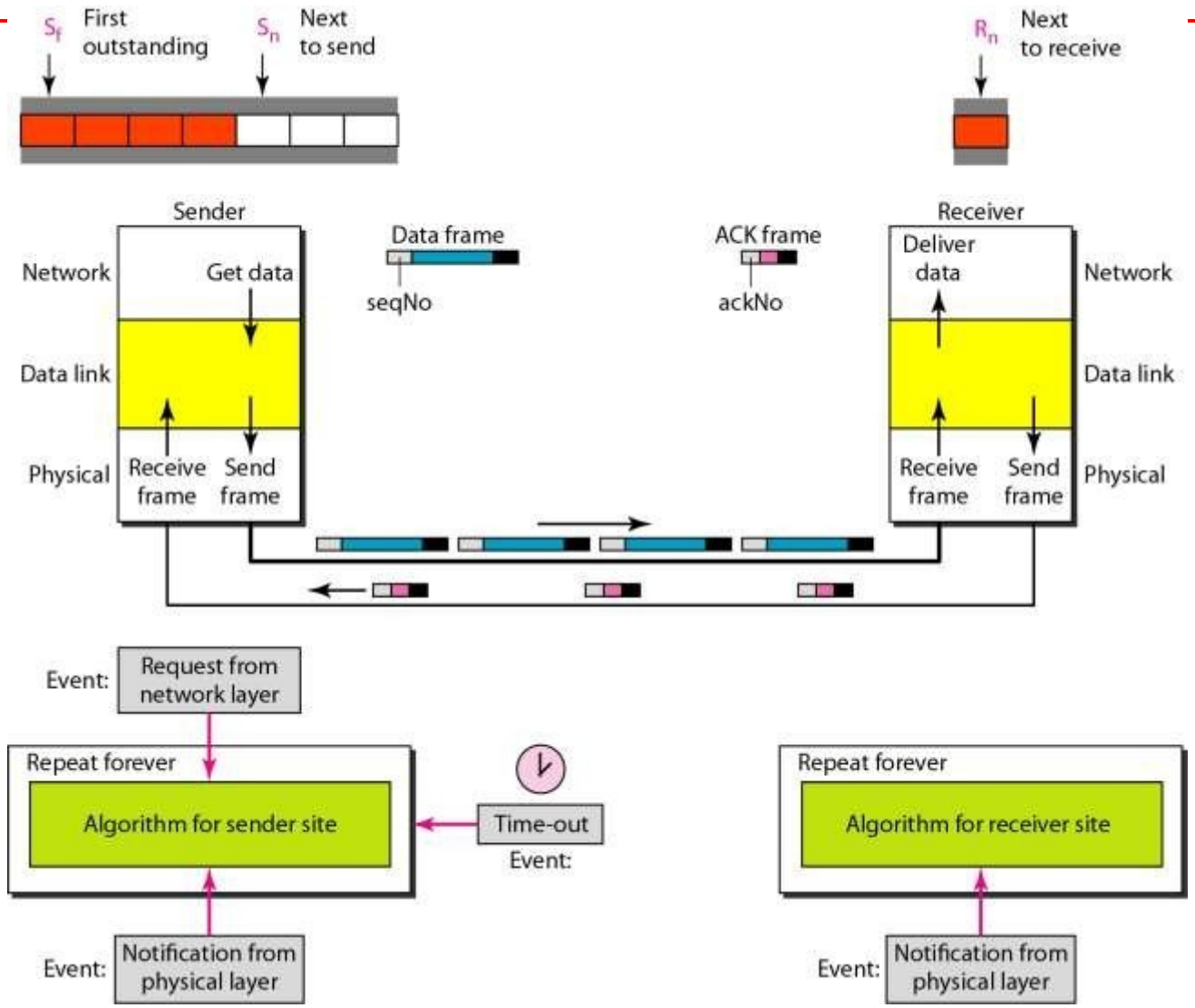
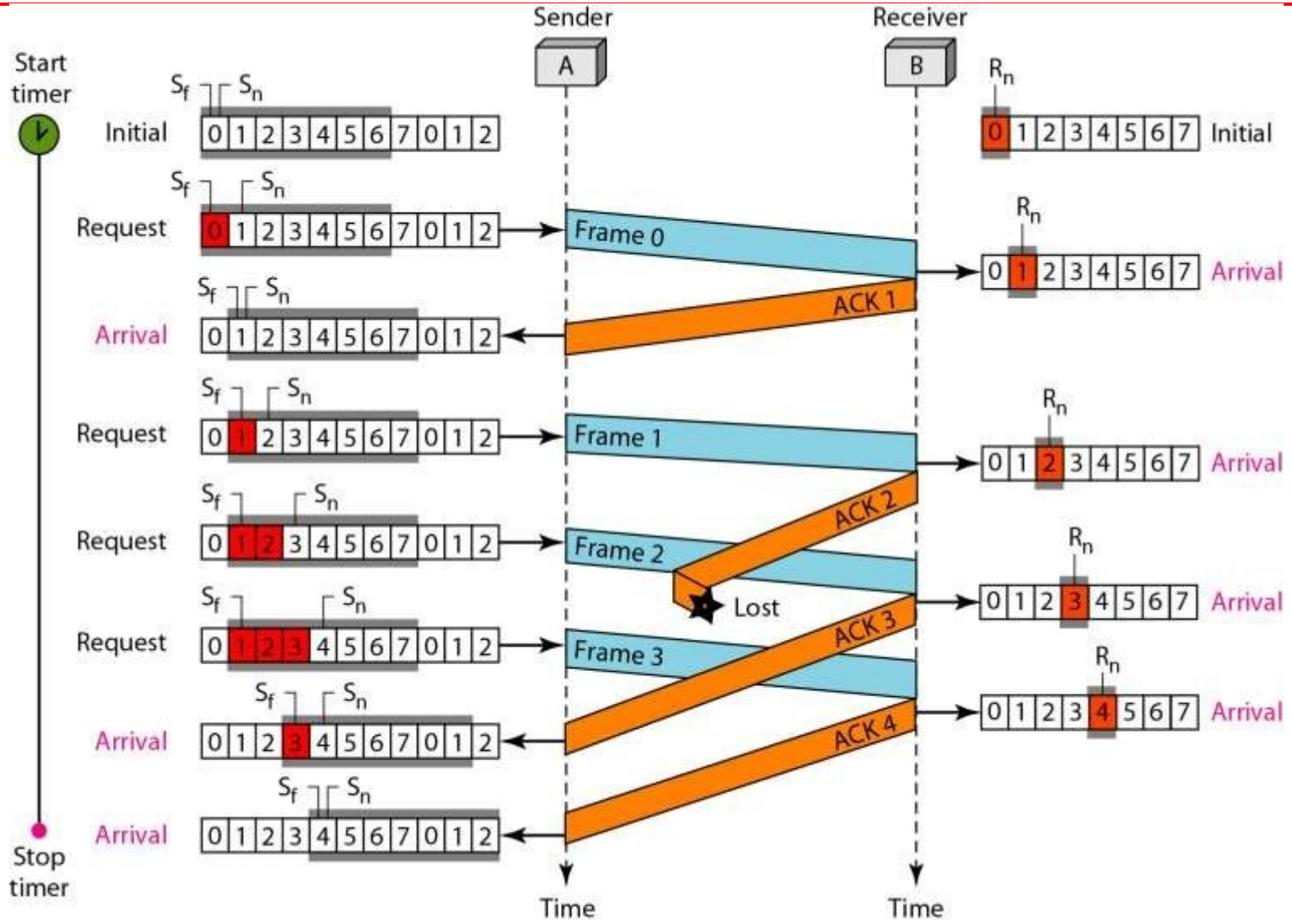
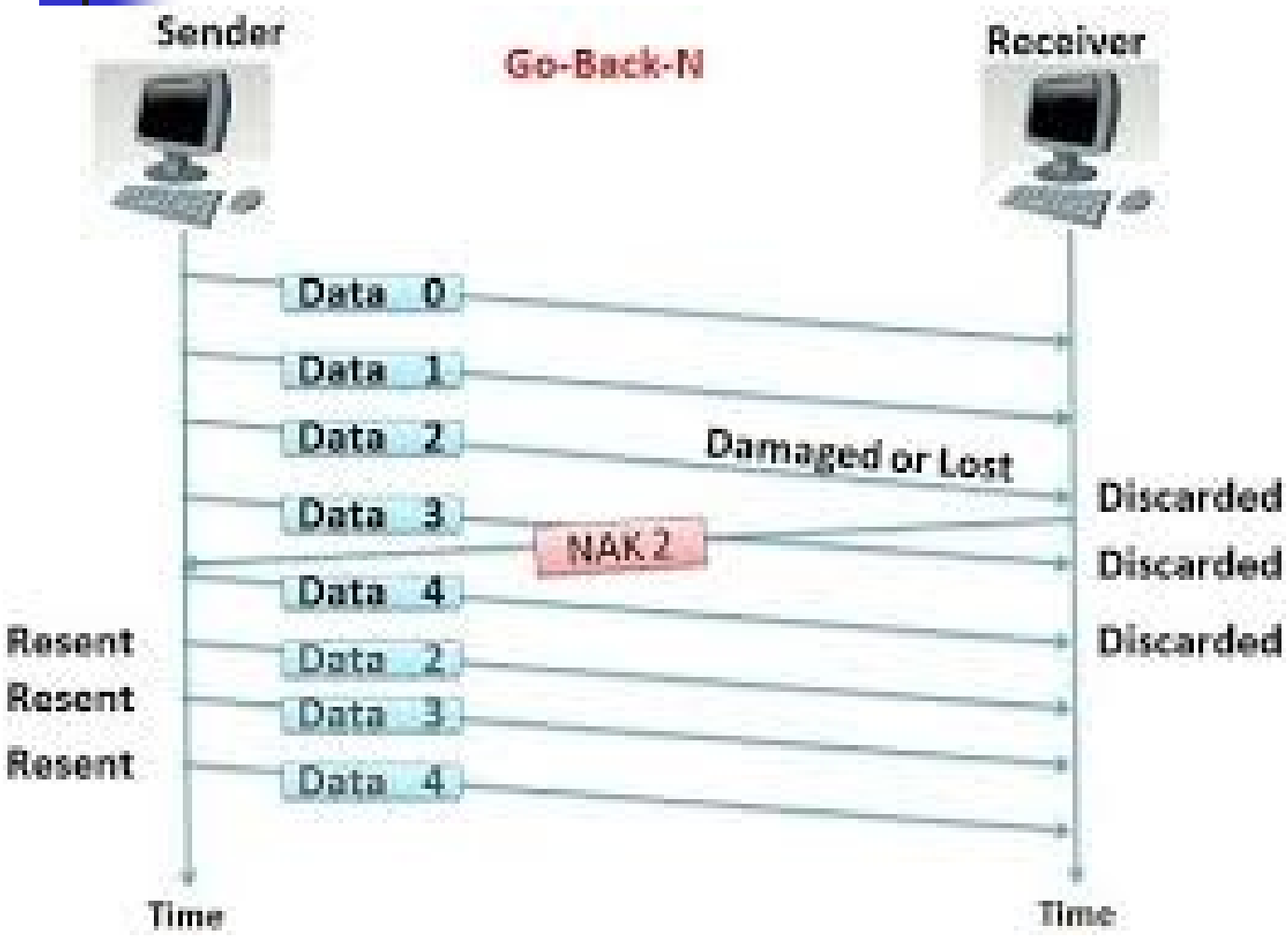


Figure 11.16 *Flow diagram for Example 11.6*




Sender
Go-Back-N
Receiver
Data 0
Data 1
Data 2
Damaged or Lost
Discarded
Data 3
NAK 2
Discarded
Data 4
Discarded
Resent
Data 2
Resent
Data 3
Resent
Data 4
Time
Time

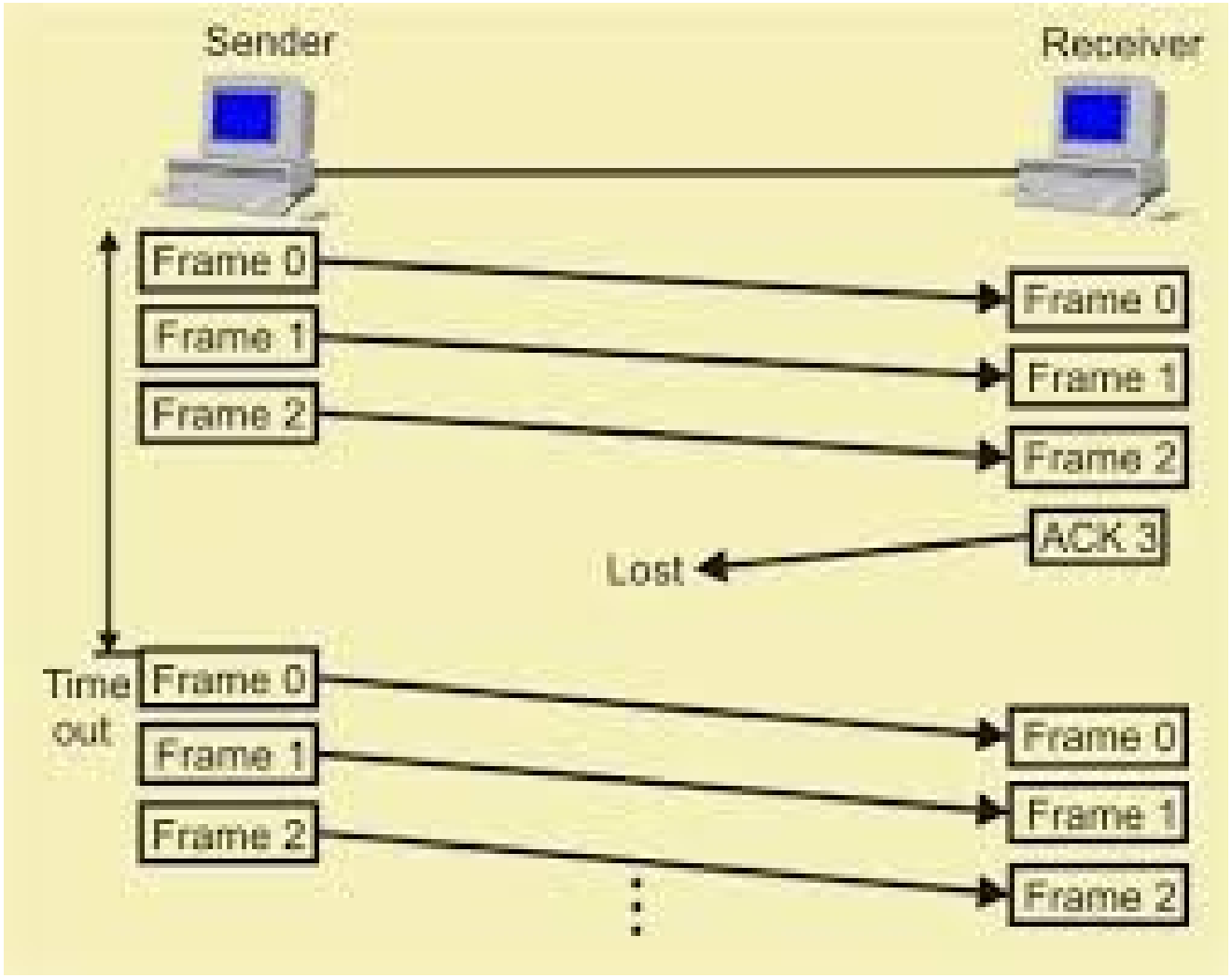

Sender
Receiver
Frame 0
Frame 1
Frame 2
Frame 0
Frame 1
Frame 2
ACK 3
Lost
Time out
Frame 0
Frame 1
Frame 2
Frame 0
Frame 1
Frame 2

Figure 11.18 Send window for Selective Repeat ARQ

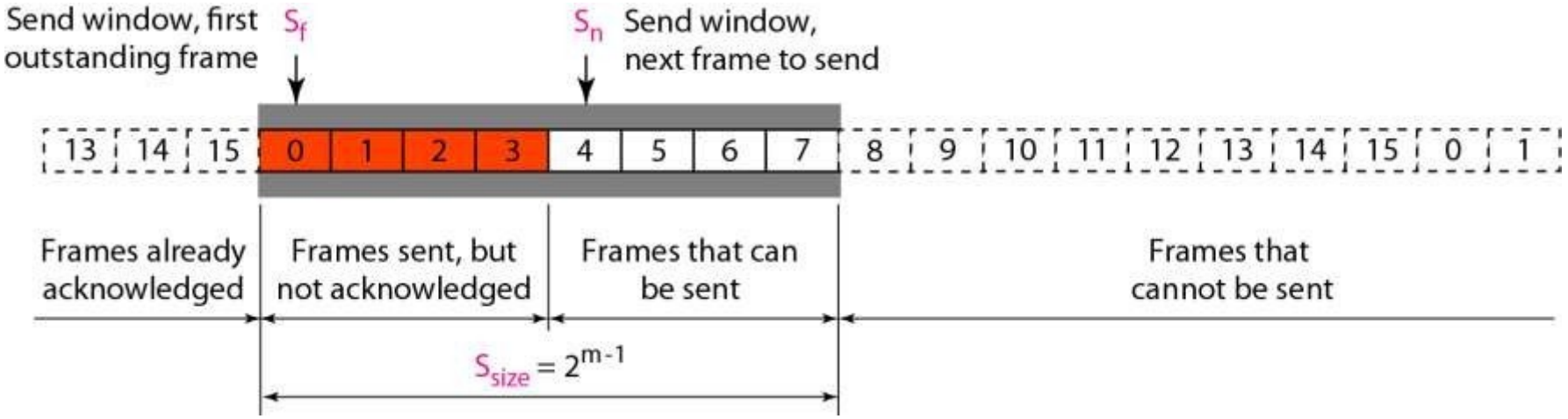


Figure 11.19 Receive window for Selective Repeat ARQ

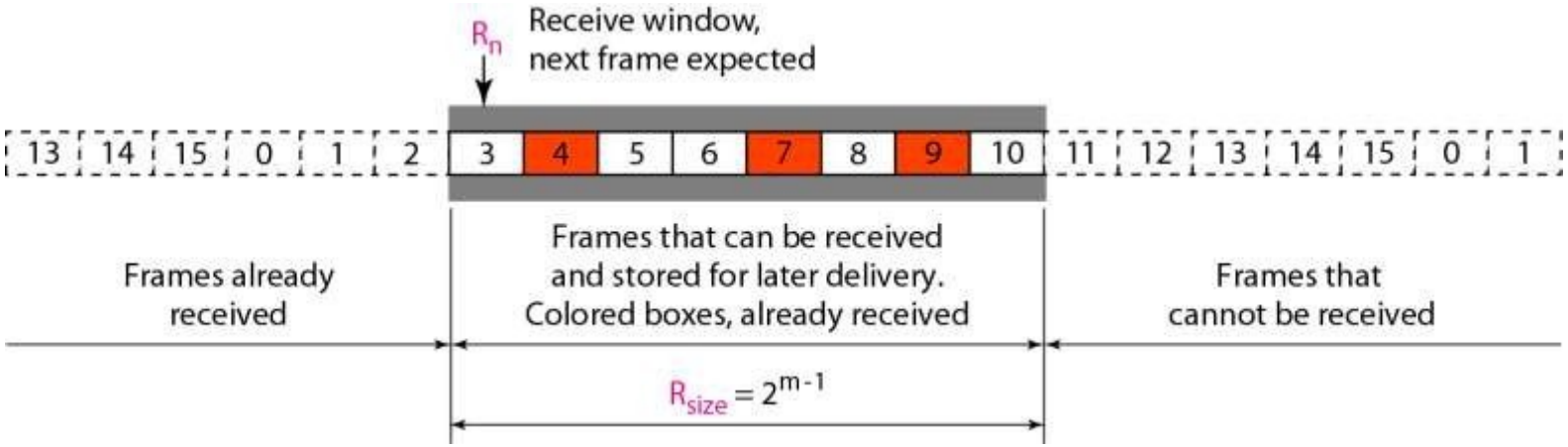


Figure 11.20 Design of Selective Repeat ARQ

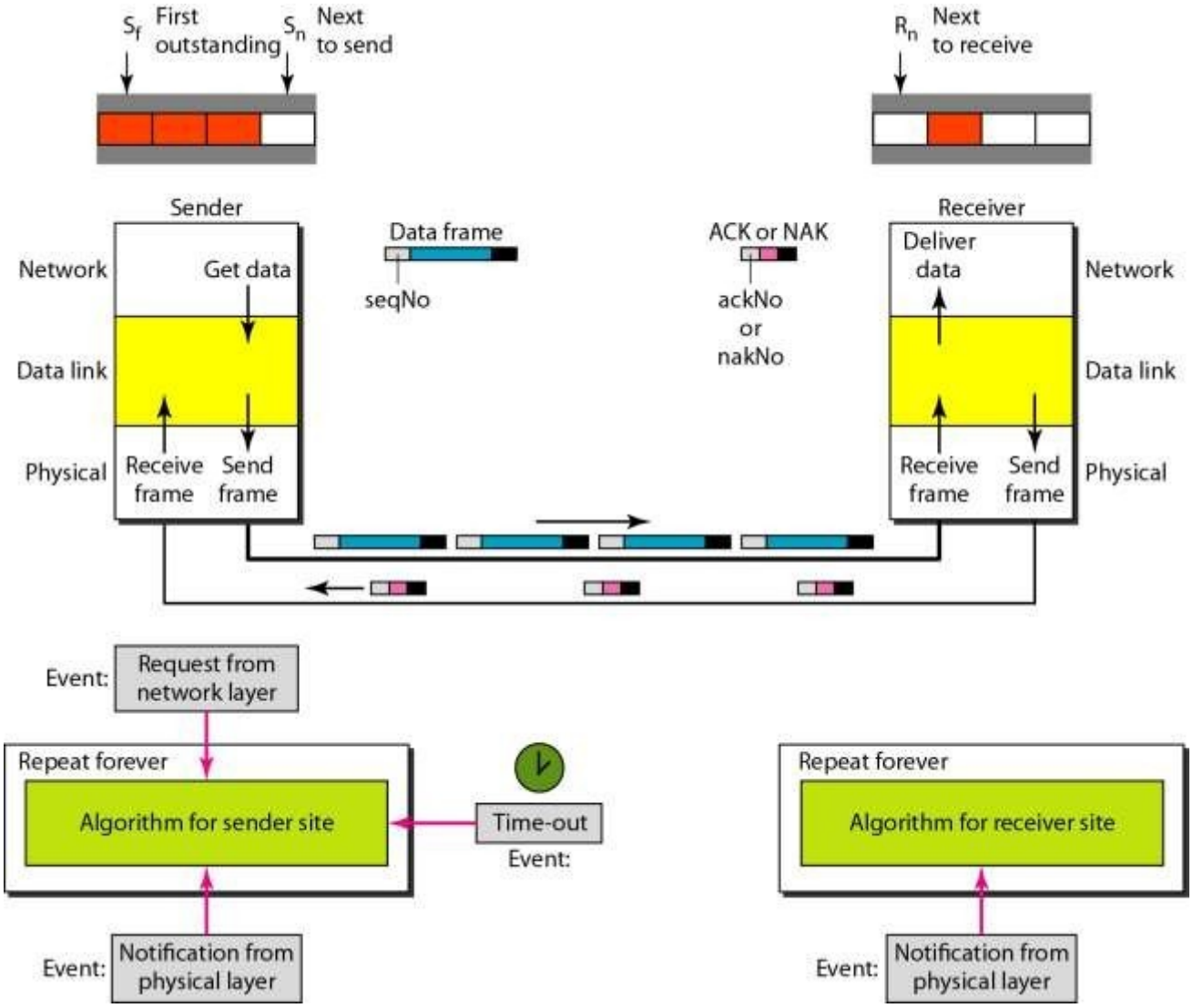
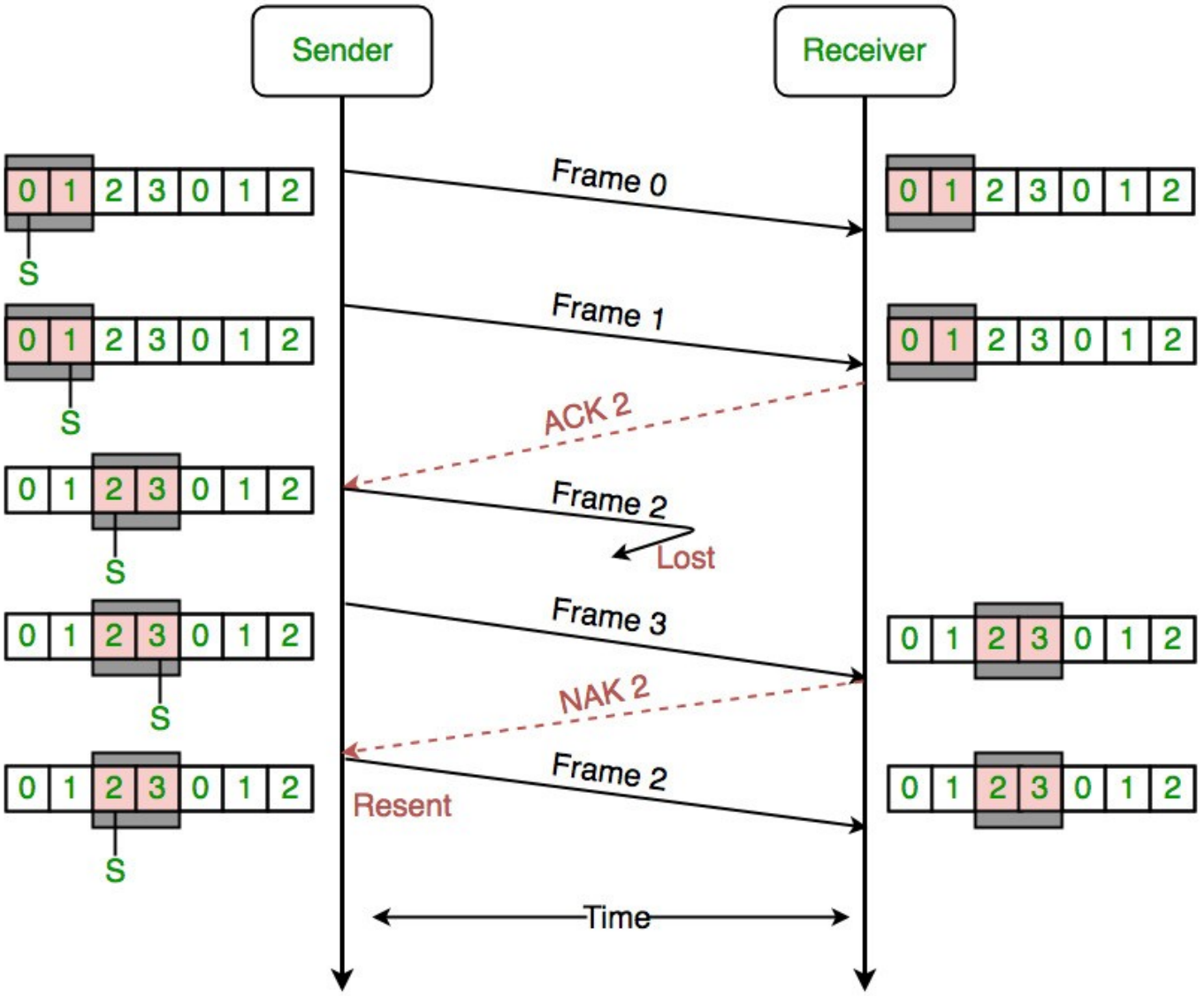


Figure 11.21 Selective Repeat ARQ, window size(2^{m-1})



Note

In Selective Repeat ARQ, the size of the sender and receiver window must be at most one-half of 2^m.