DATA LINK CONTROL

Data Link Layer Design Issues

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

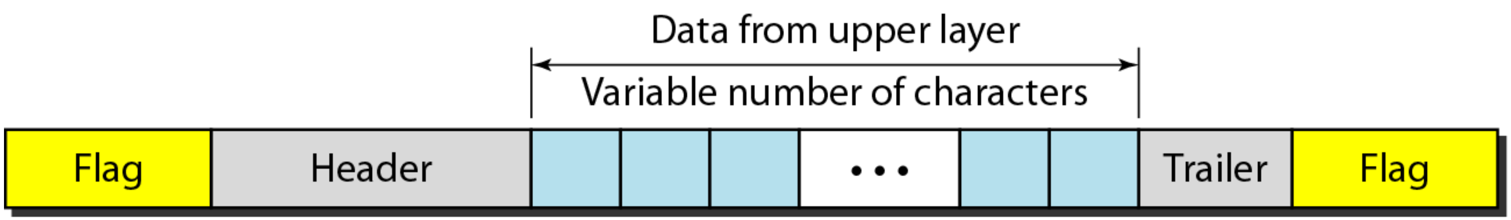
Topics discussed in this section:

Fixed-Size Framing
Variable-Size Framing

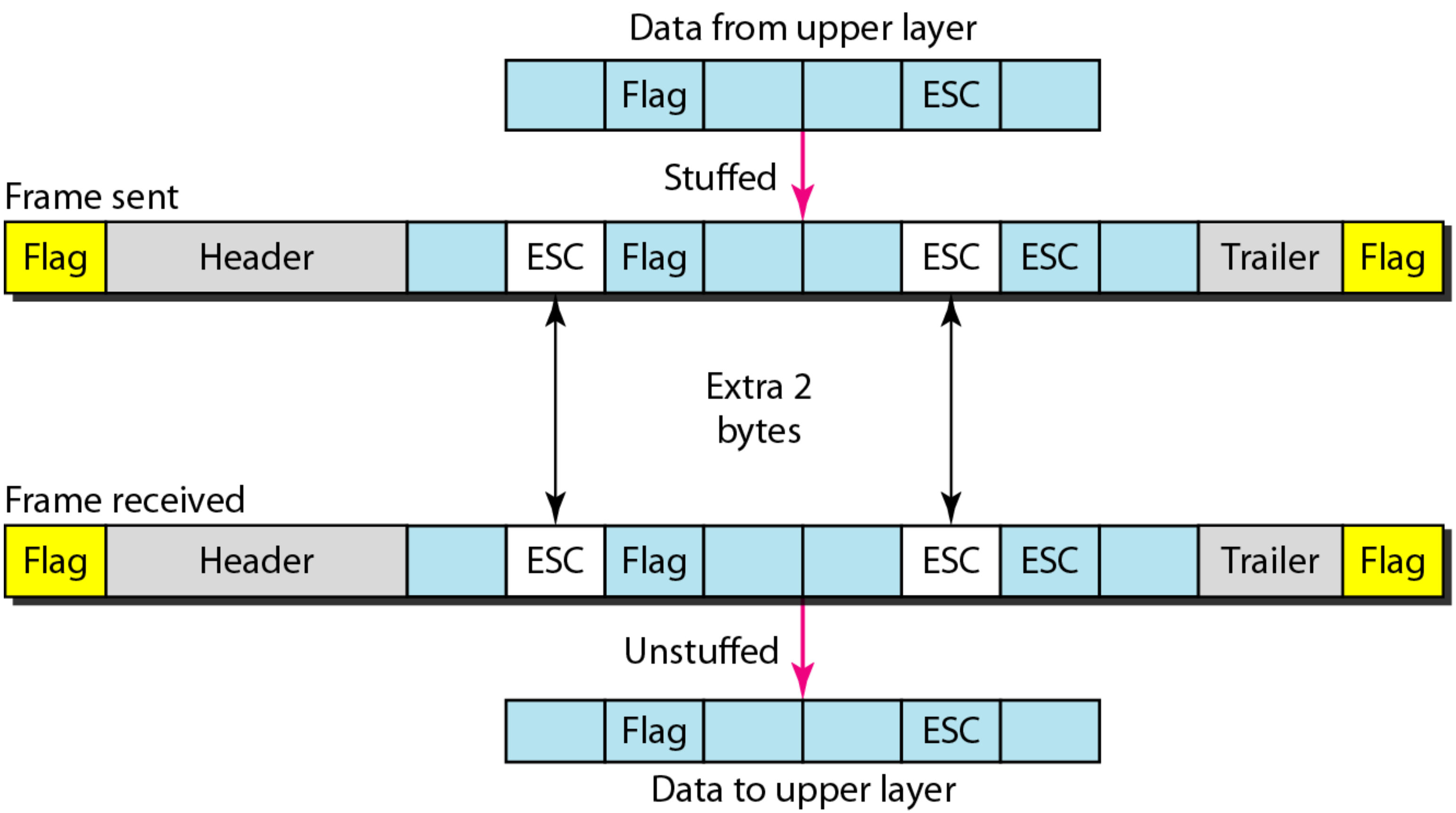
Types of Framing

- Fixed Size Framing
- Variable Size Framing--- Character oriented protocols and Bit oriented Protocols.

A frame in a character-oriented protocol



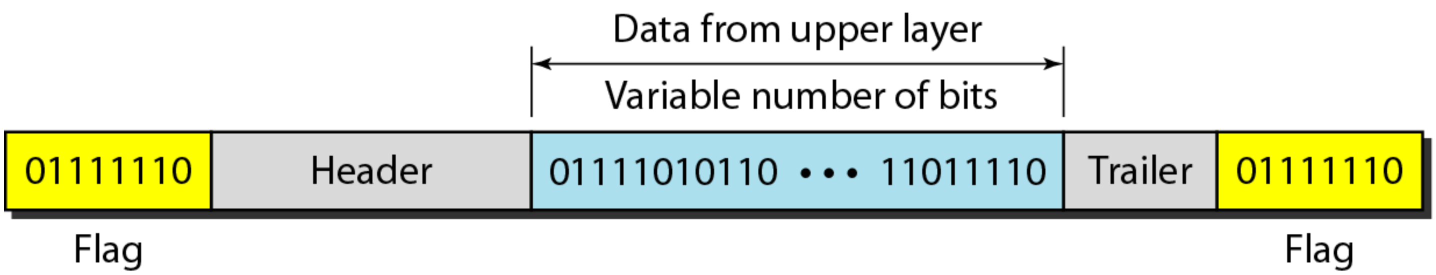
Byte stuffing and unstuffing



Note

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

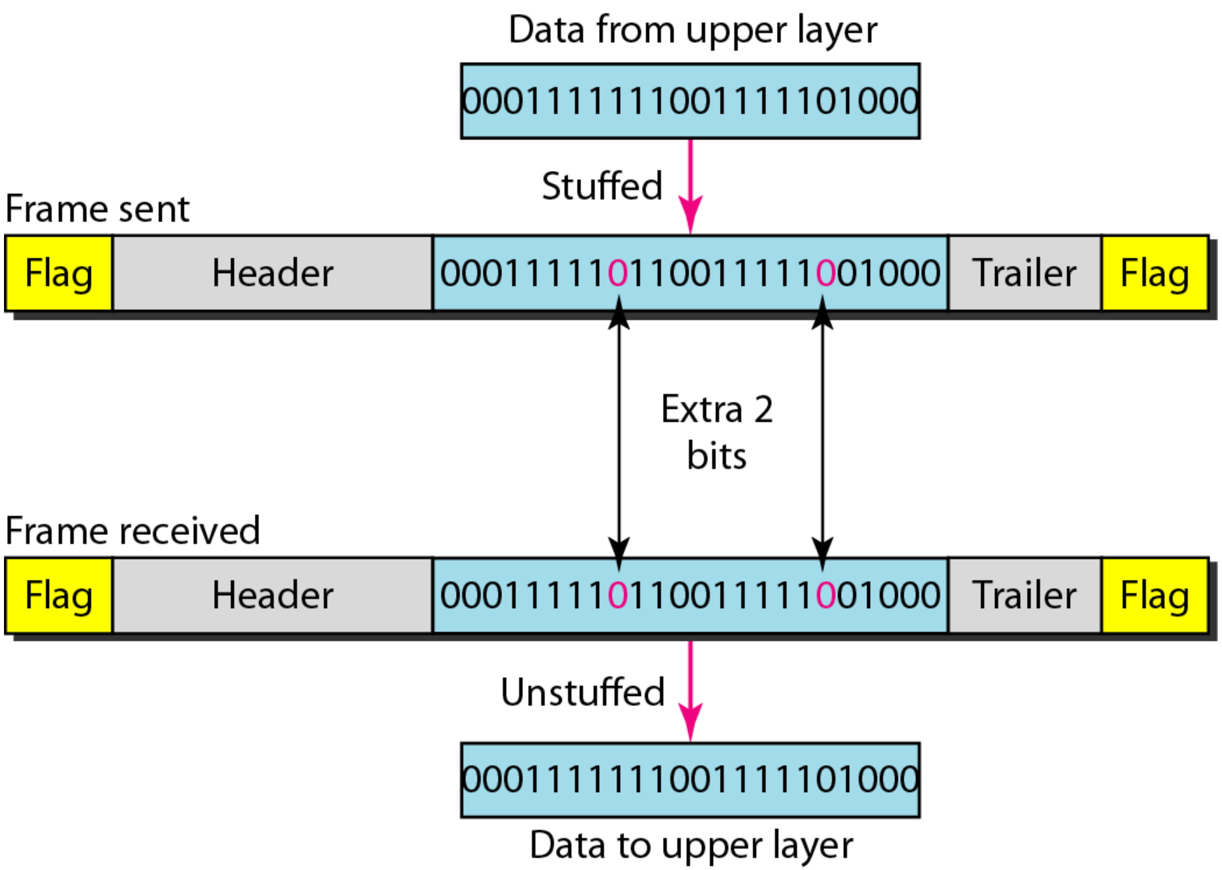
A frame in a bit-oriented protocol



Note

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 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.

Topics discussed in this section:

Flow Control
Error Control

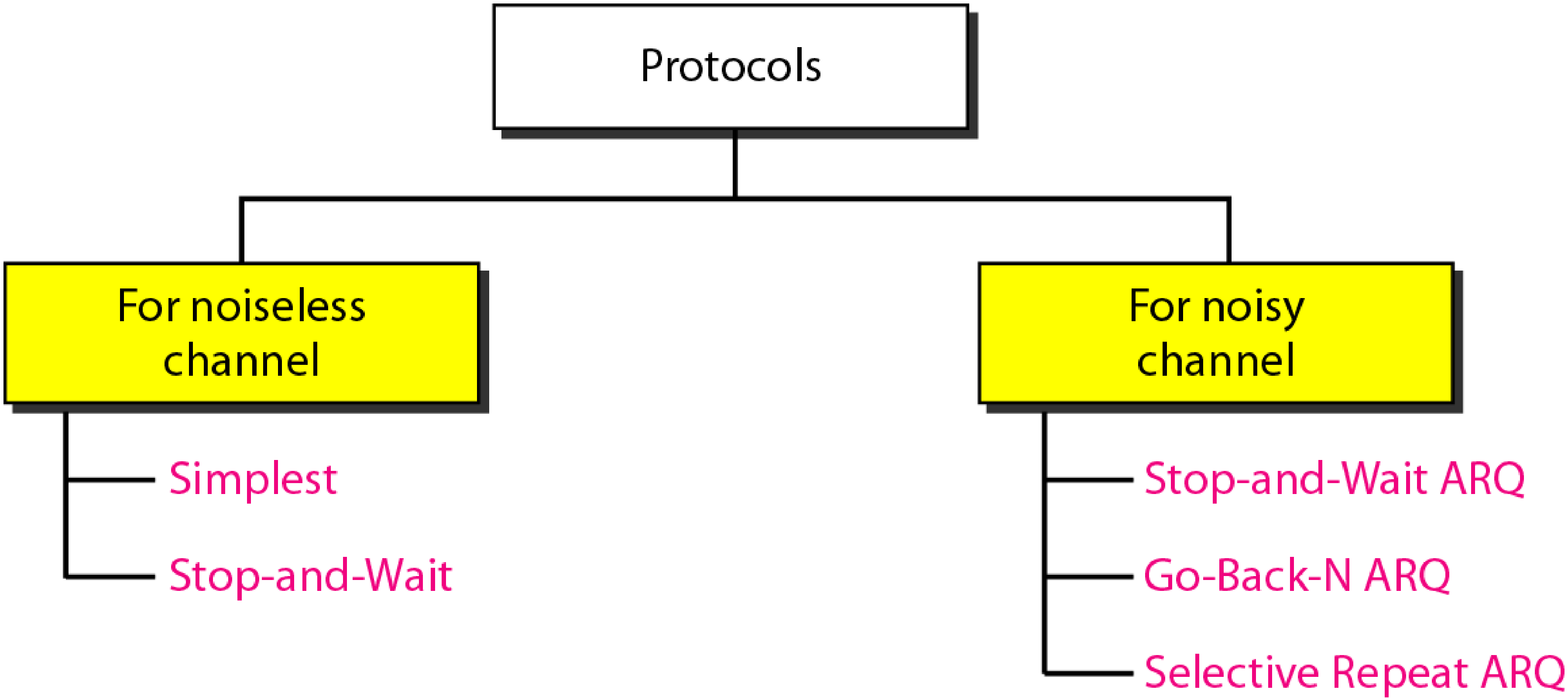
Note

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

Note

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

Taxonomy of protocols discussed in this chapter



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.

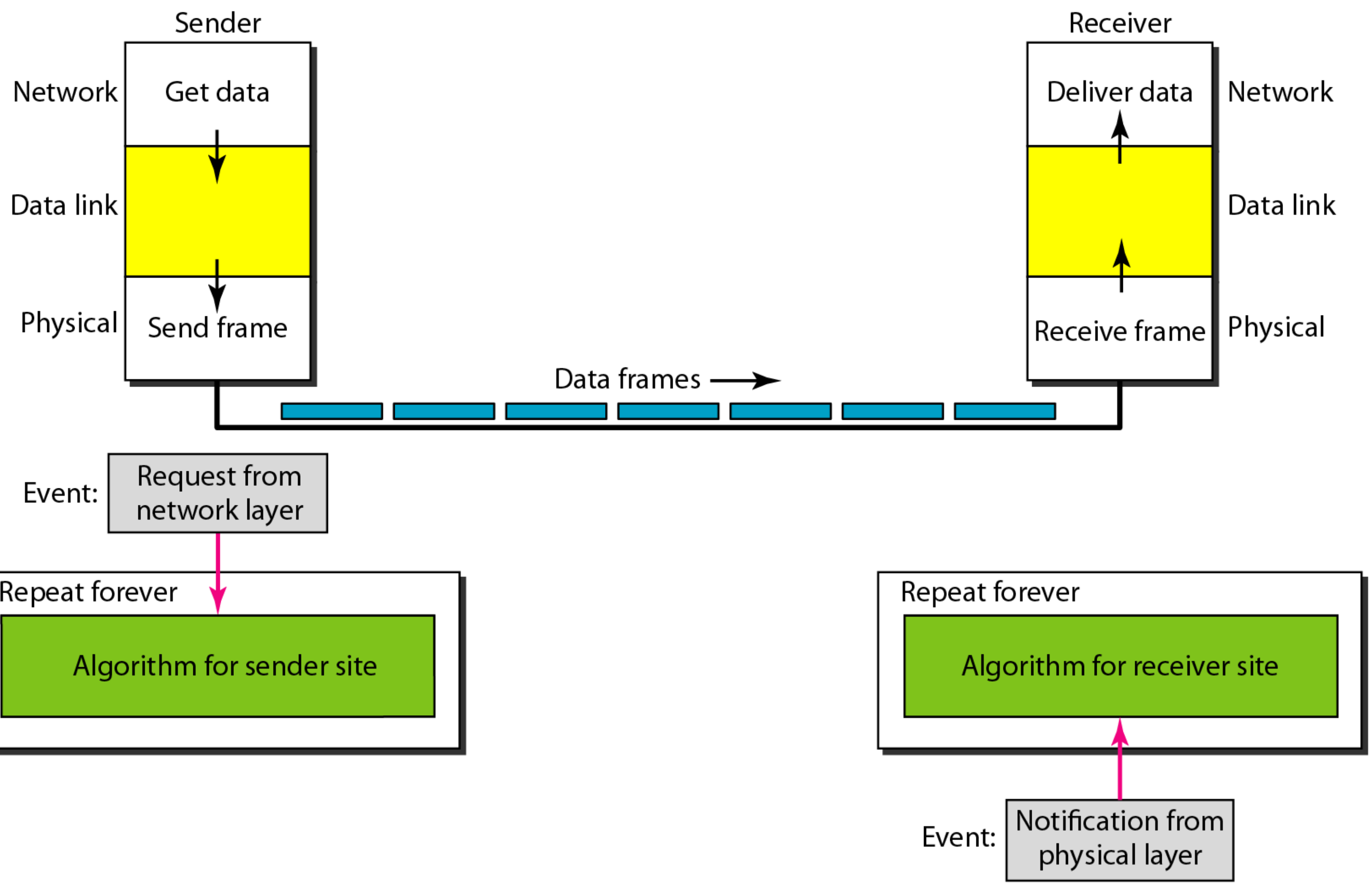
Topics discussed in this section:

Simplest Protocol
Stop-and-Wait Protocol

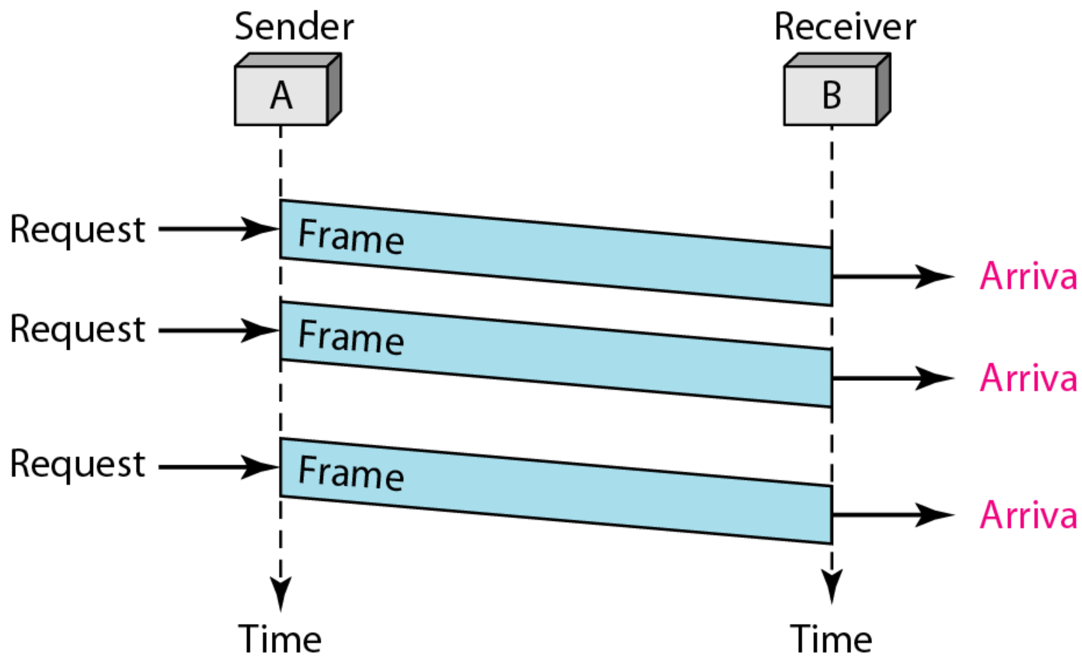
Simplest Protocol

- No flow and Error Control

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



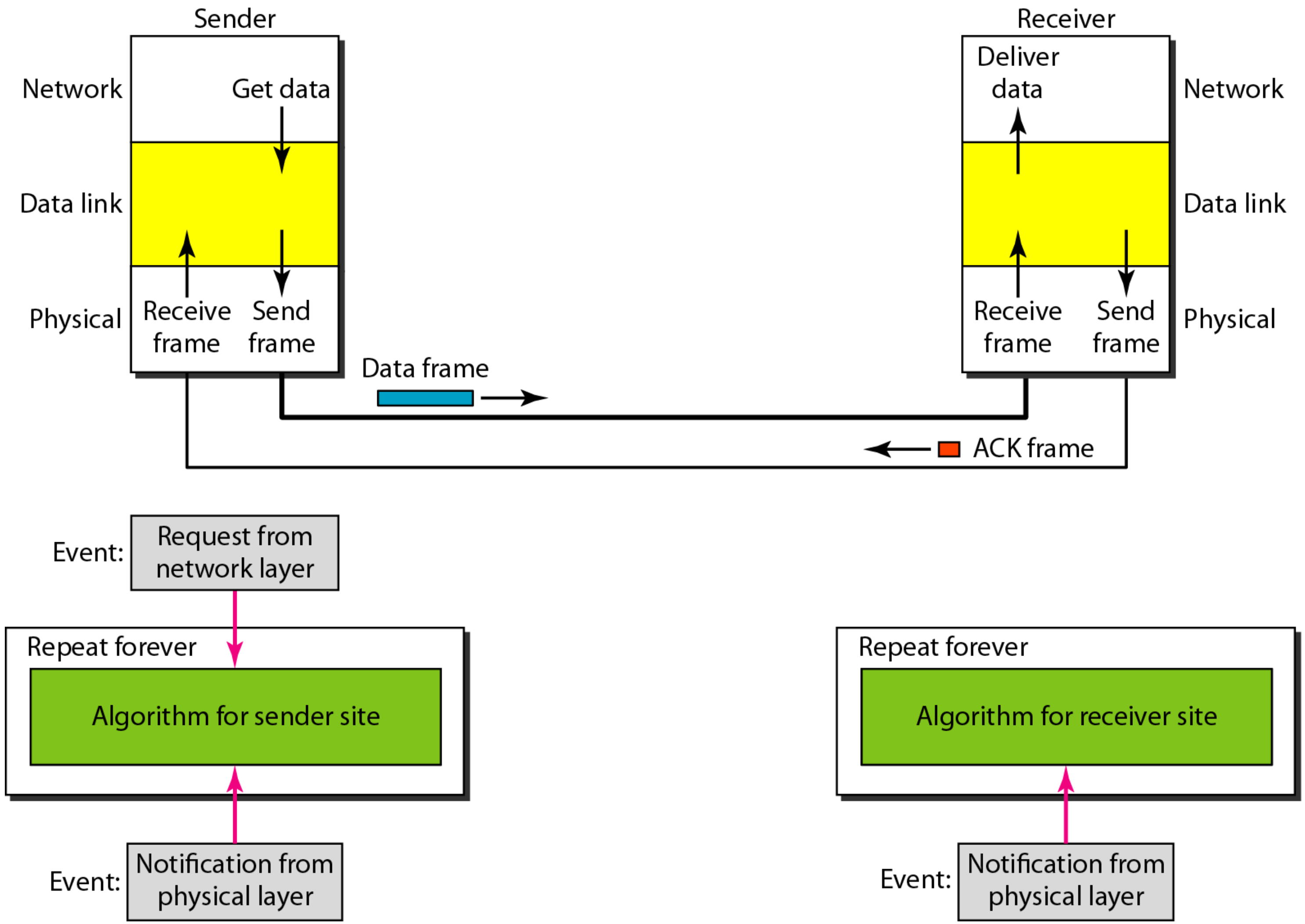
Flow diagram for Simplest



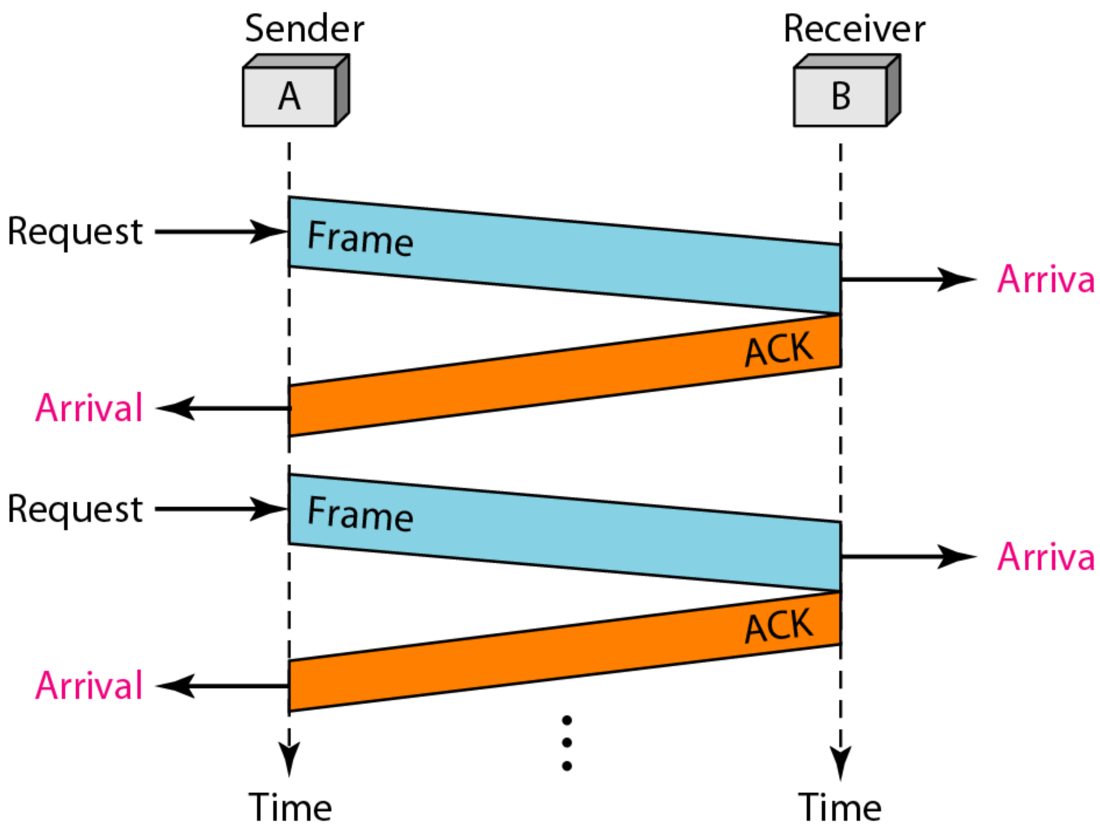
Stop-and-Wait Protocol

- Sender sends one frame, stops until it gets confirmation from receiver.

Design of Stop-and-Wait Protocol



Flow diagram for Stop and Wait



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

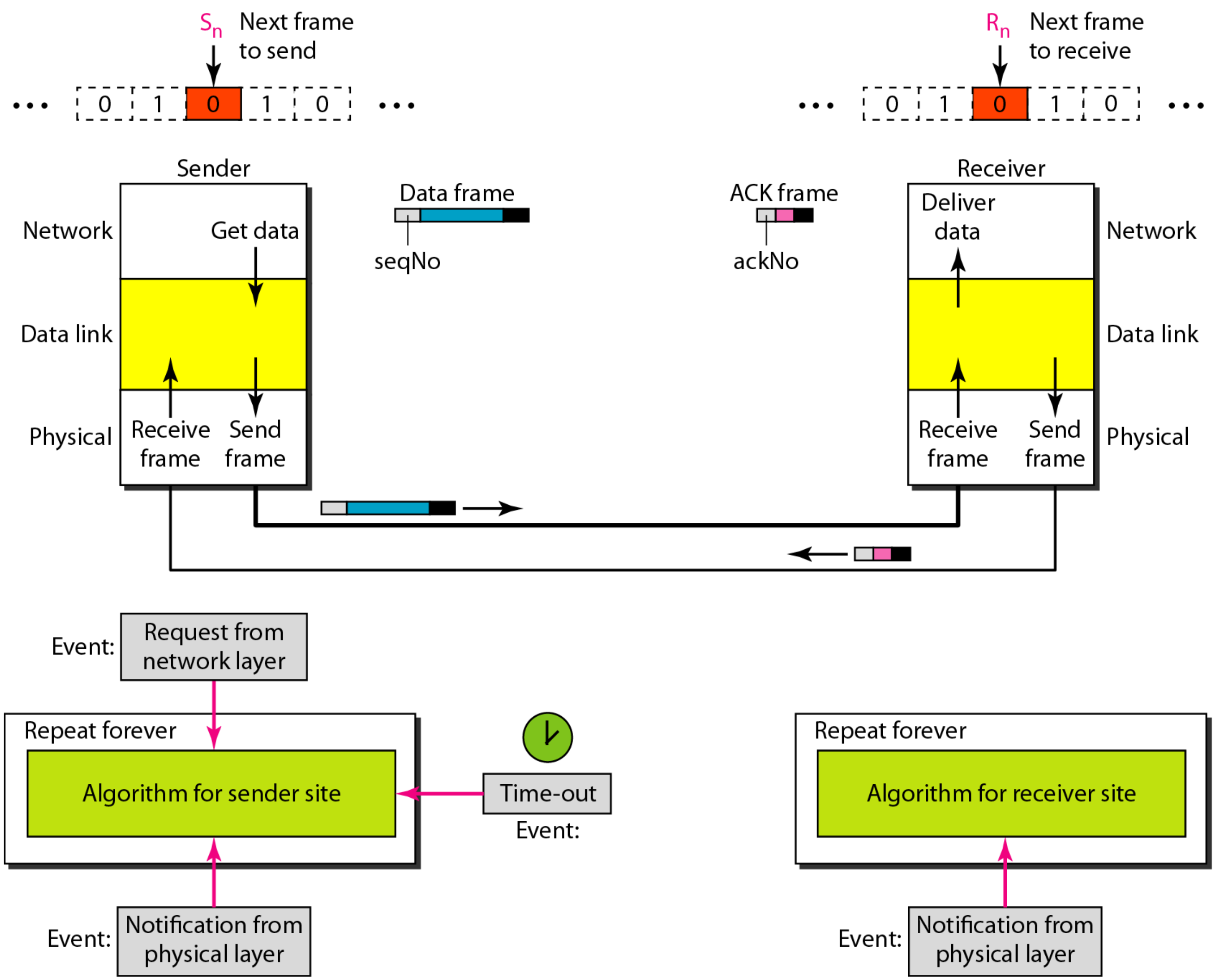
Note

**In Stop-and-Wait ARQ, we use sequence numbers to number the frames.
The sequence numbers can be 1,0,1,0,1…**

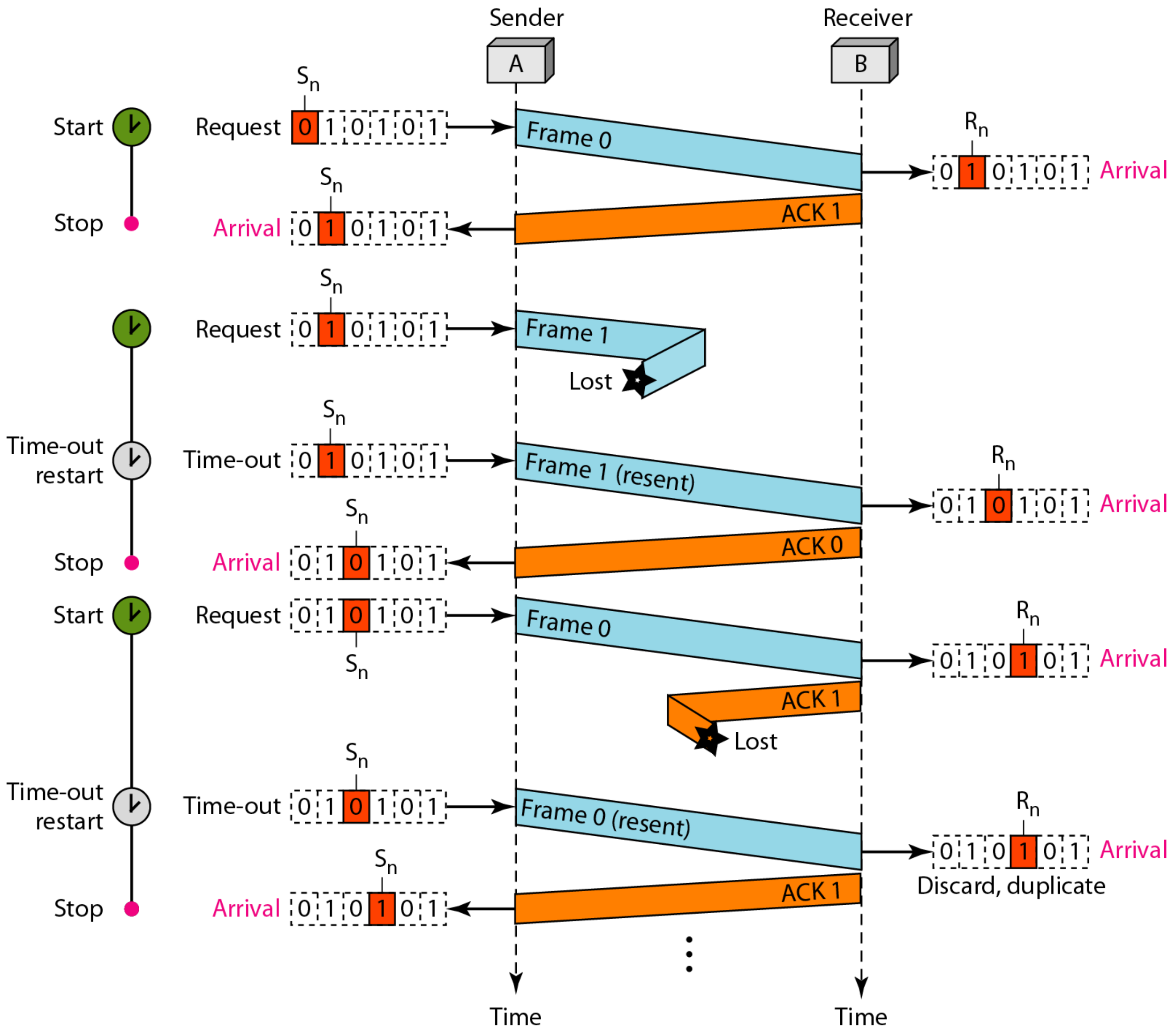
Note

In Stop-and-Wait ARQ, the acknowledgment number is 0 if sequence number is 1 and acknowledgment number is 1 if sequence number is 0

Design of the Stop-and-Wait ARQ Protocol



Flow diagram for Example 11.3



Disadvantage ***Stop-and-Wait ARQ Protocol***

- Inefficient---if channel is thick and long
- Thick means high bandwidth
- Long means roundtrip delay
- Product of both is bandwidth delay.
- Bandwidth delay is number of bits we can send while waiting for news from receiver.

Assume that, in a Stop-and-Wait ARQ system, the bandwidth of the line is 1 Mbps, and 1 bit takes 20 ms to make a round trip. What is the bandwidth-delay product? If the system data frames are 1000 bits in length, what is the utilization percentage of the link?

Solution

The bandwidth-delay product is

$$(1 \times 10^6) \times (20 \times 10^{-3}) = 20{,}000 \text{ bits}$$

Pipelining

- Task begins before end of first task.
- ***Stop-and-Wait ARQ does not use pipelining but other two techniques do.***

- ***This improves efficiency.***

Go-Back-N Protocol

- This sends multiple frames before receiving acknowledgment from receiver.

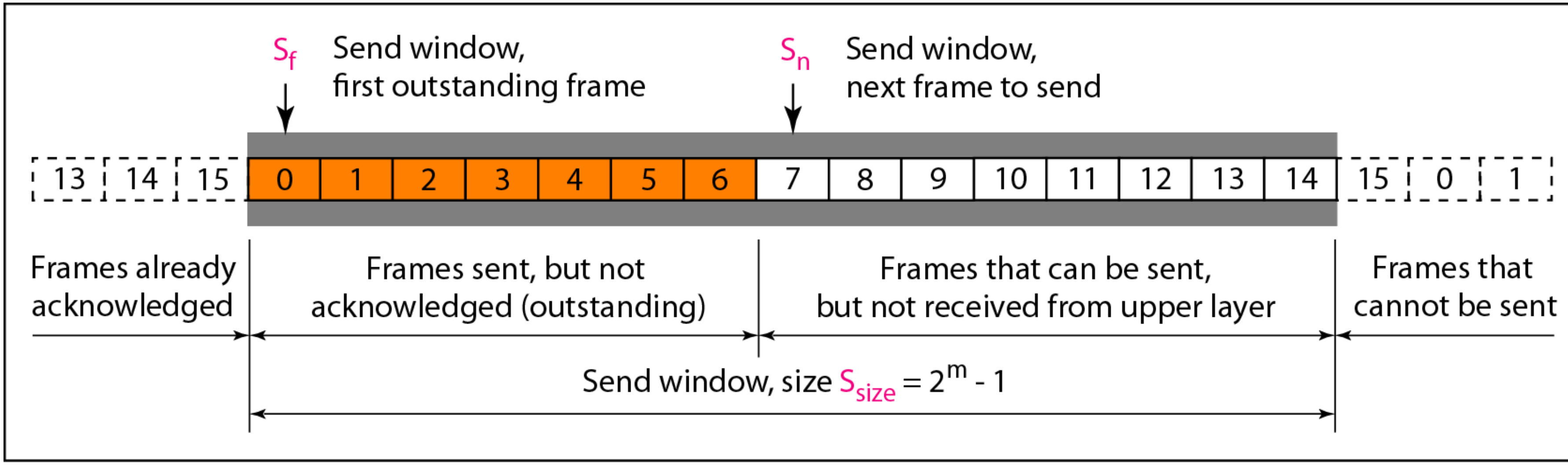
Note

In the Go-Back-N Protocol, the sequence numbers are modulo 2^m, where m is the size of the sequence number field in bits.

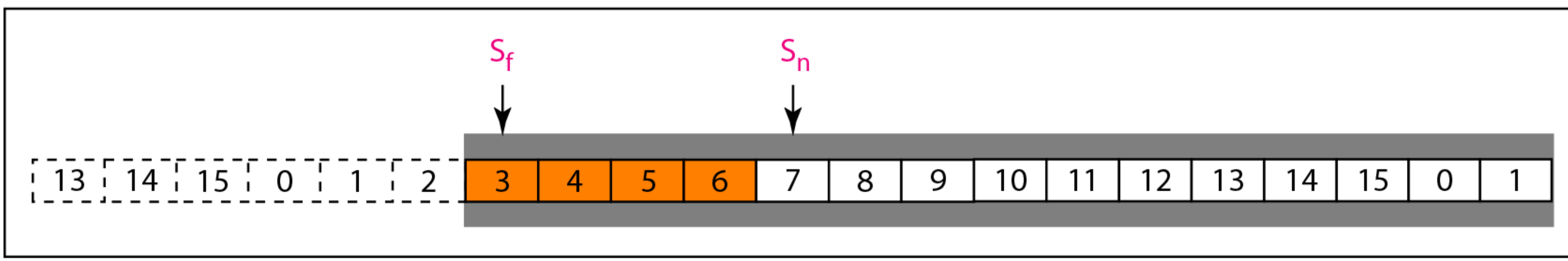
Sliding Window

- Defines the range of sequence numbers that is concern of sender and receiver.
- The range which is concern of sender is called sender sliding window.
- The range which is concern of receiver is called receiver sliding window.

Send window for Go-Back-N ARQ



a. Send window before sliding



b. Send window after sliding

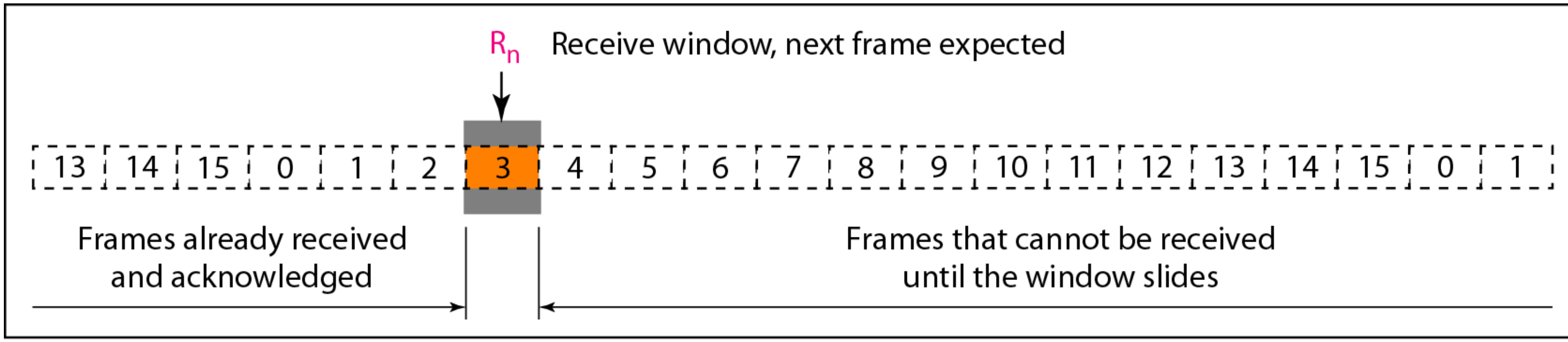
Note

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}.

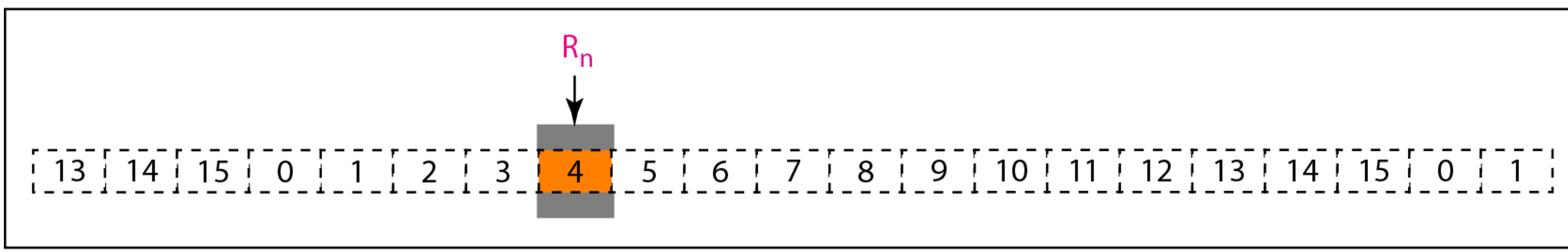
Note

The send window can slide one or more slots when a valid acknowledgment arrives.

Receive window for Go-Back-N ARQ



a. Receive window

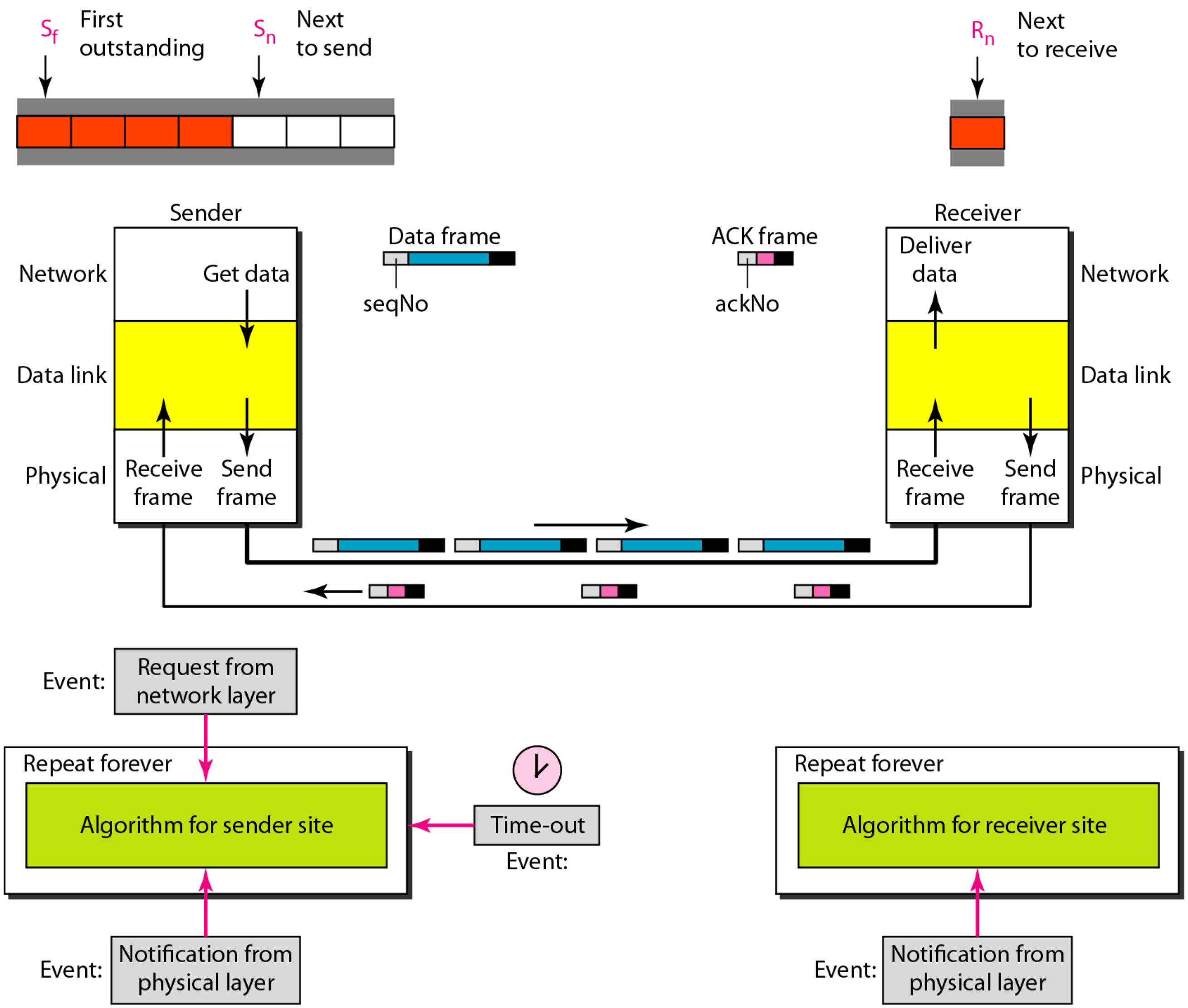


b. Window after sliding

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.

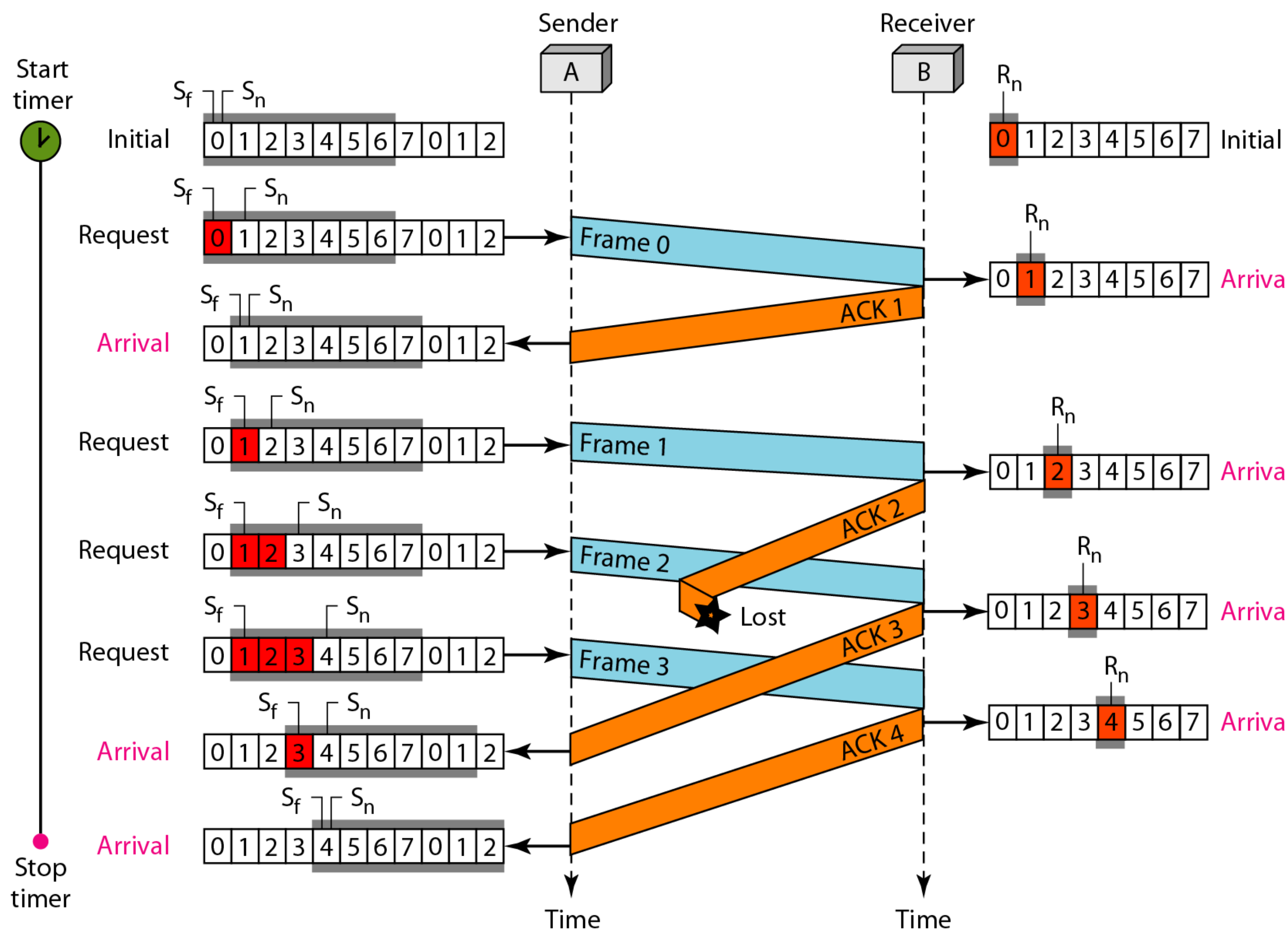
Design of Go-Back-N ARQ



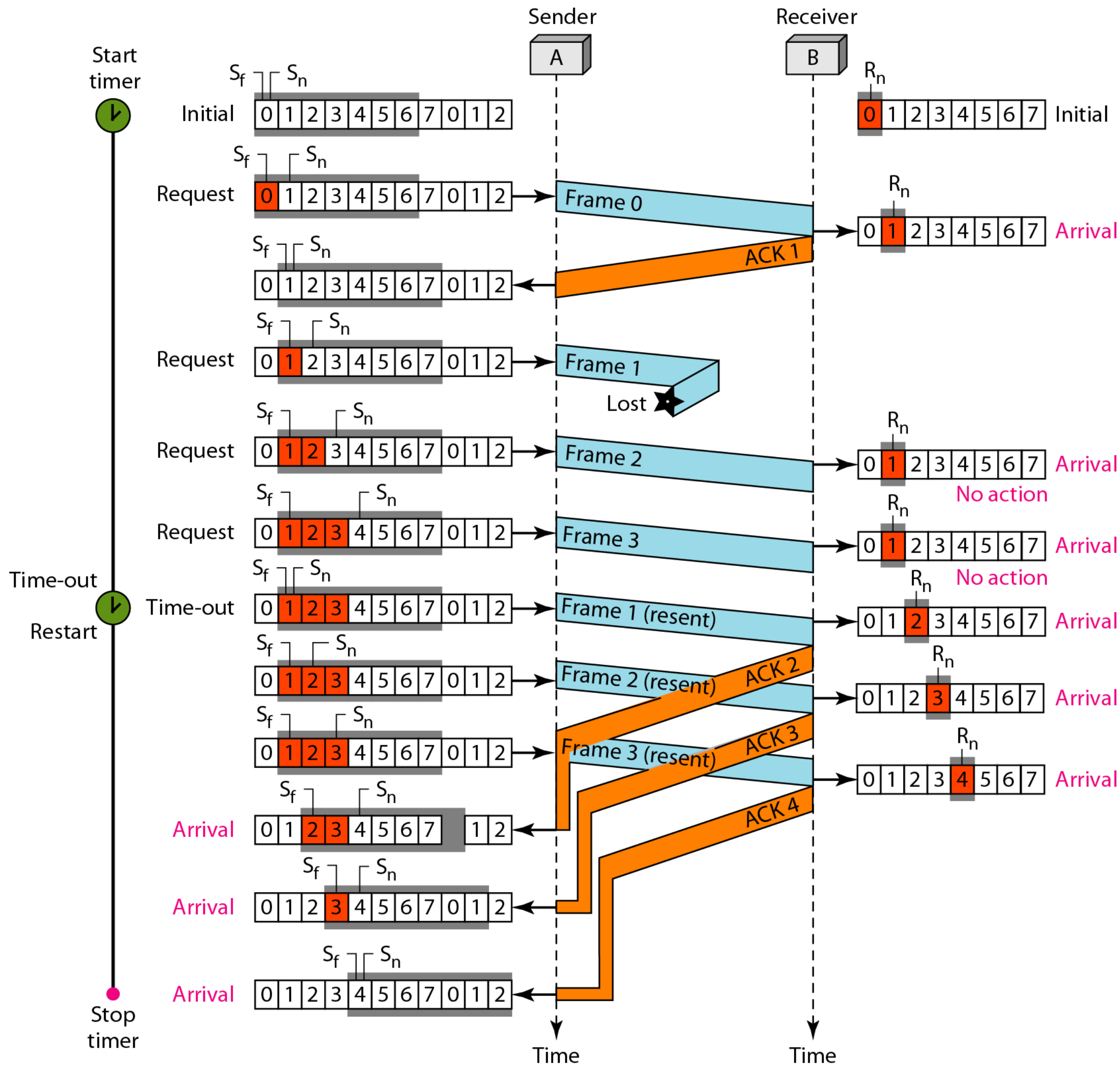
Note

In Go-Back-N ARQ, the size of the send window must be less than 2^m; the size of the receiver window is always 1.

Flow diagram



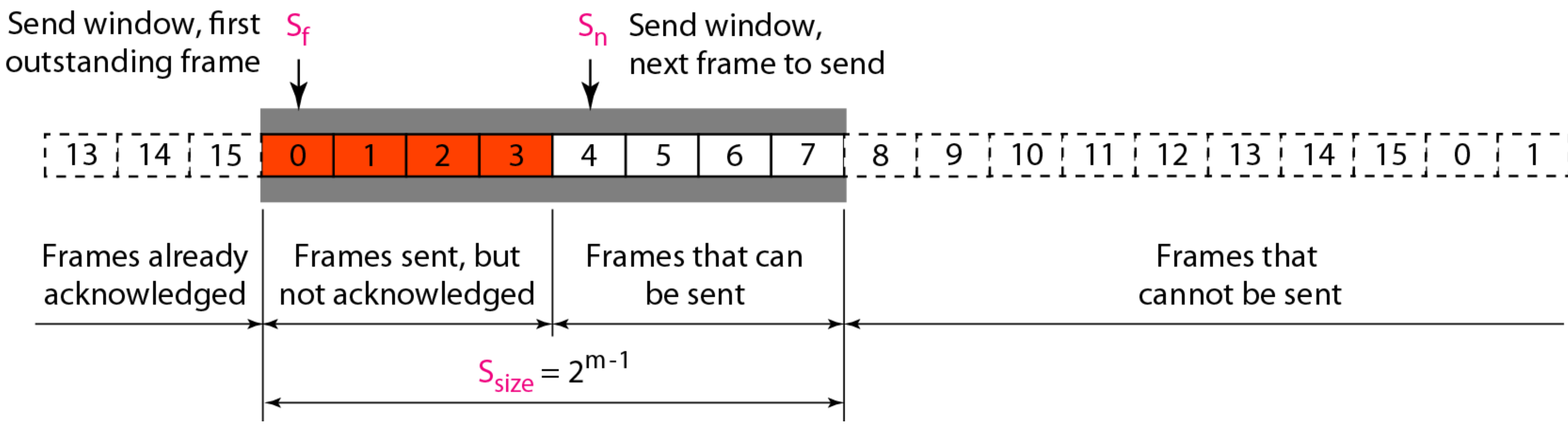
Flow diagram



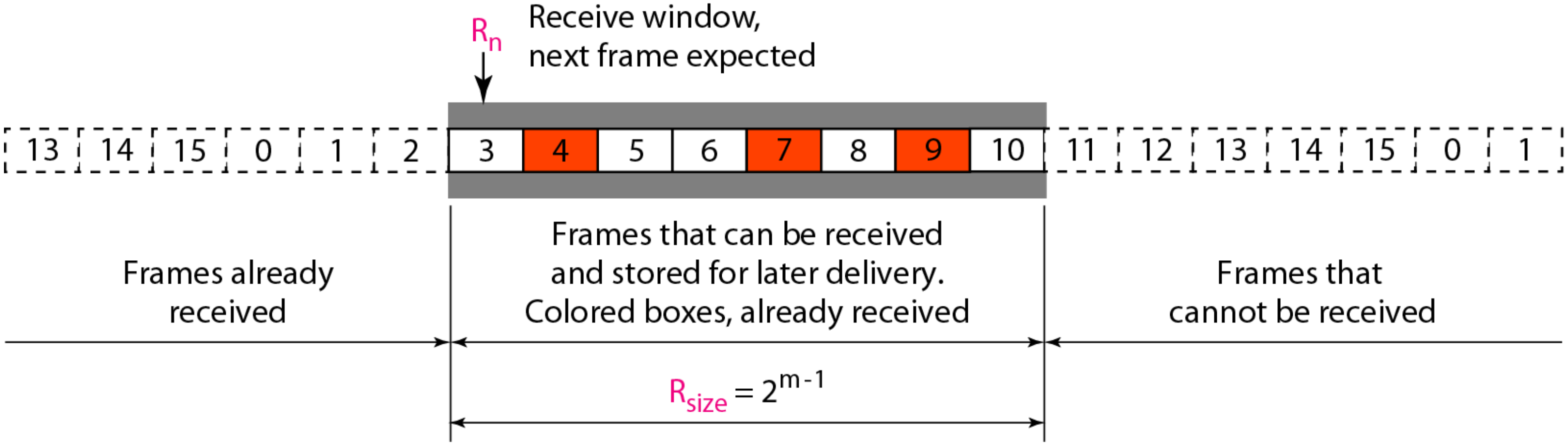
Note

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

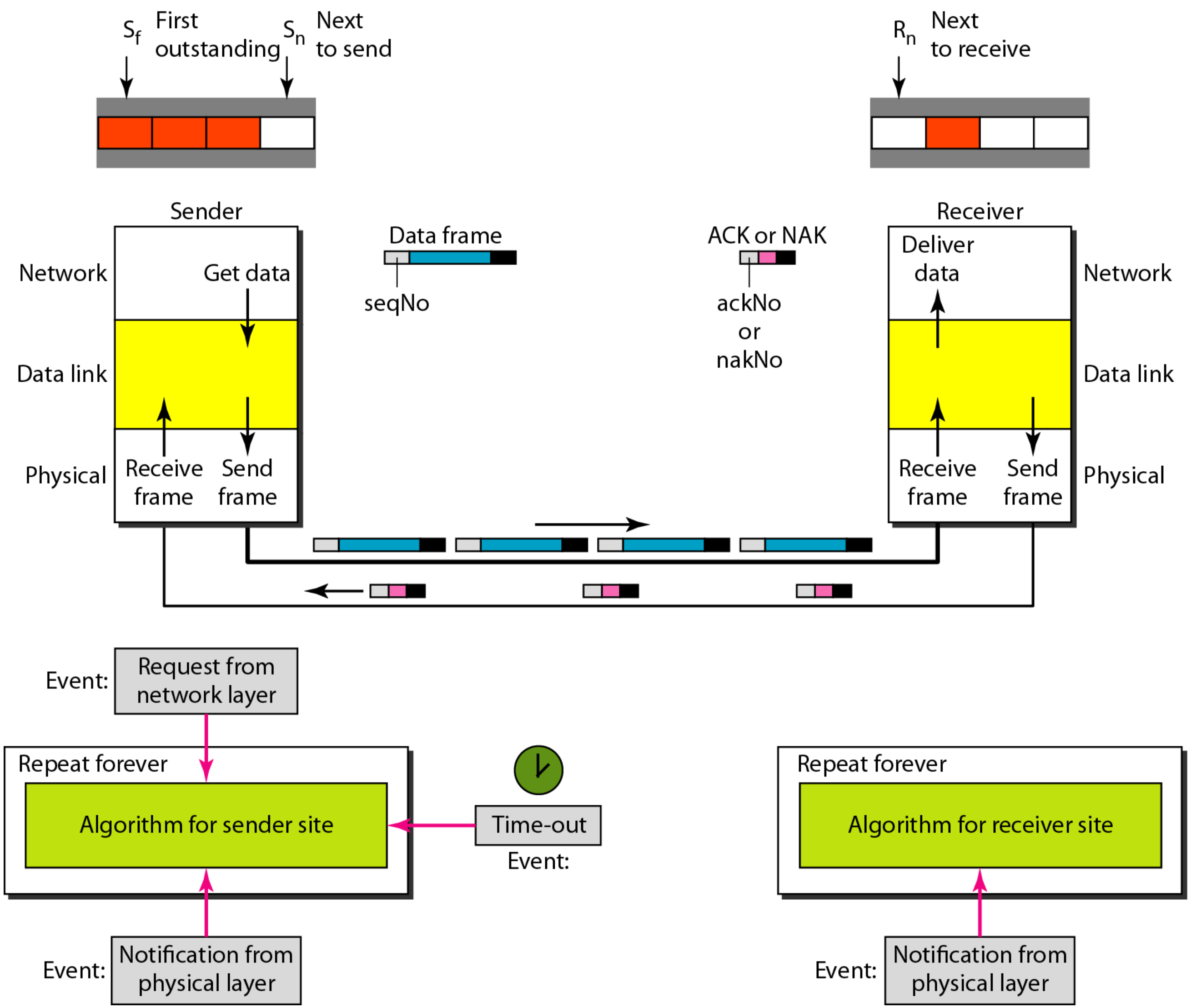
Send window for Selective Repeat ARQ



Receive window for Selective Repeat ARQ



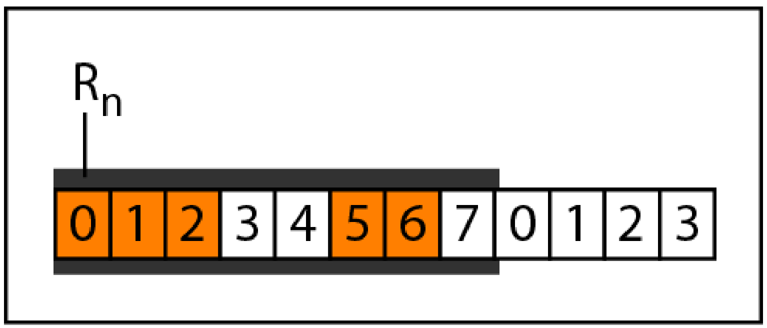
Design of Selective Repeat ARQ



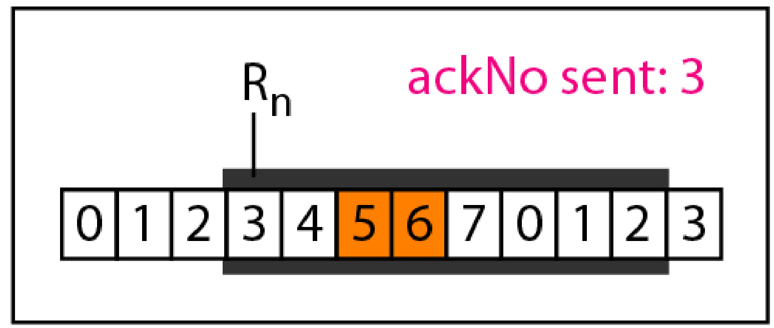
Note

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

Delivery of data in Selective Repeat ARQ

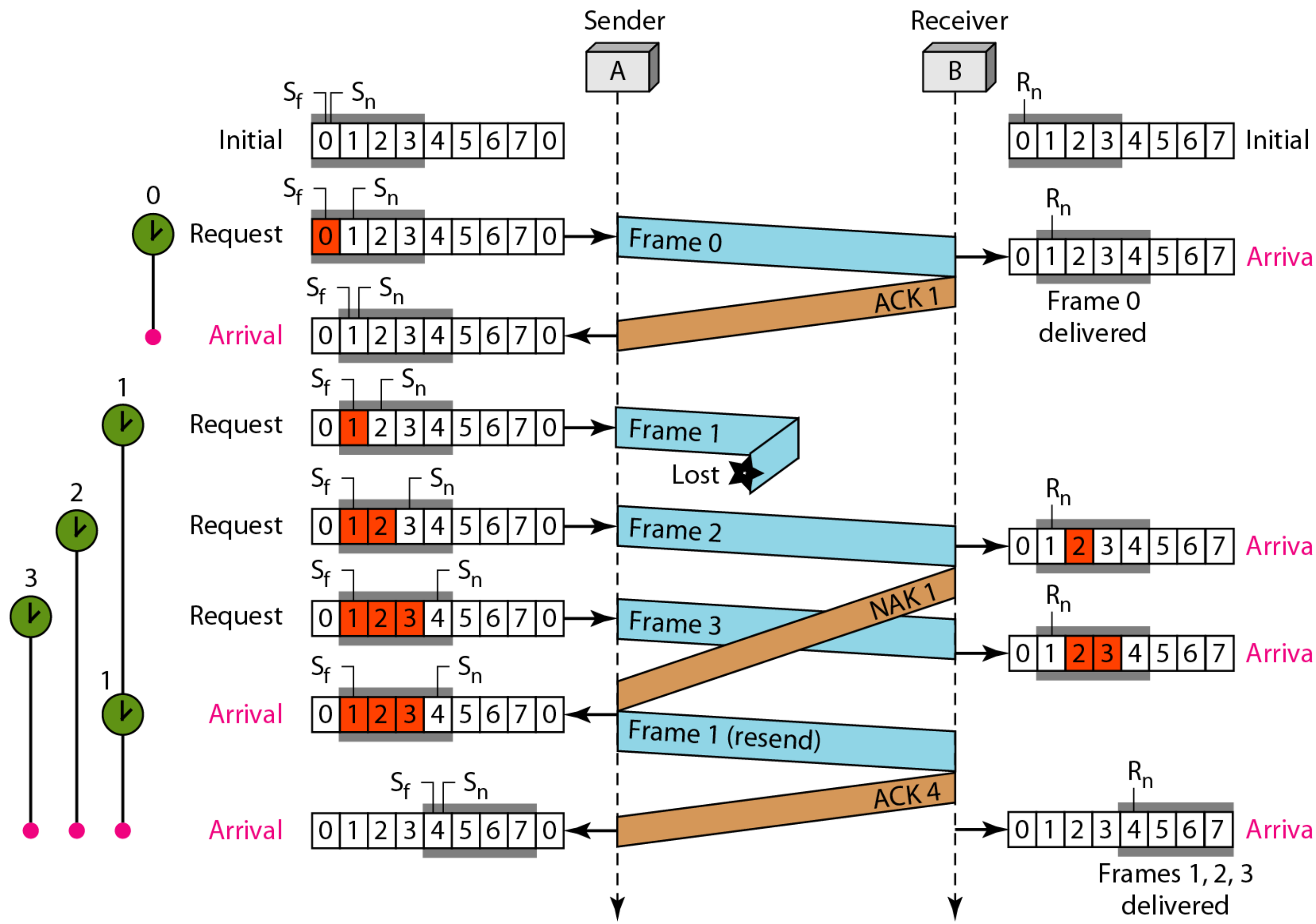


a. Before delivery



b. After delivery

Flow diagram



Design of piggybacking in Go-Back-N ARQ