DATA LINK CONTROL

Data Link Layer Design Issues

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

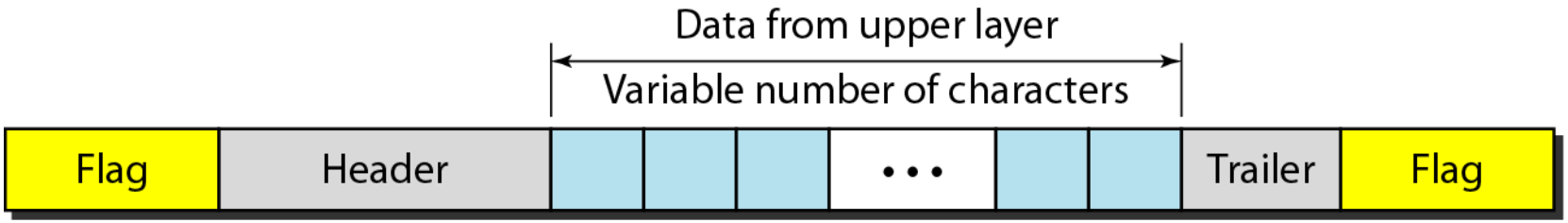
FRAMING

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.

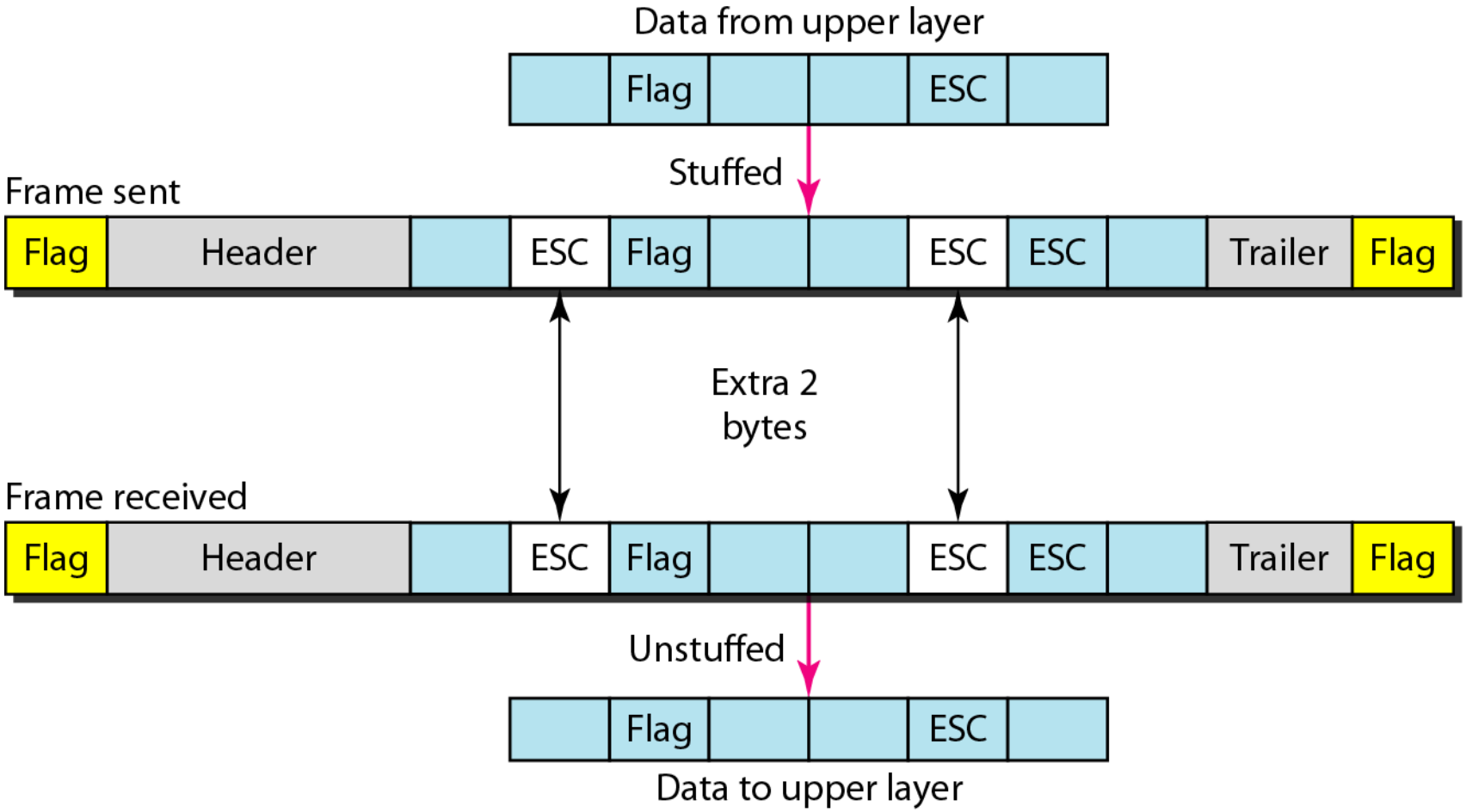
Types of Framing

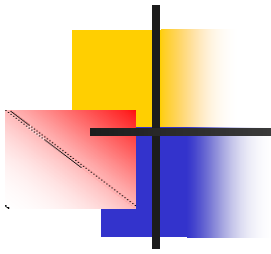
- Fixed Size Framing
- Variable Size Framing

A frame in a character-oriented protocol



Byte stuffing and unstuffing

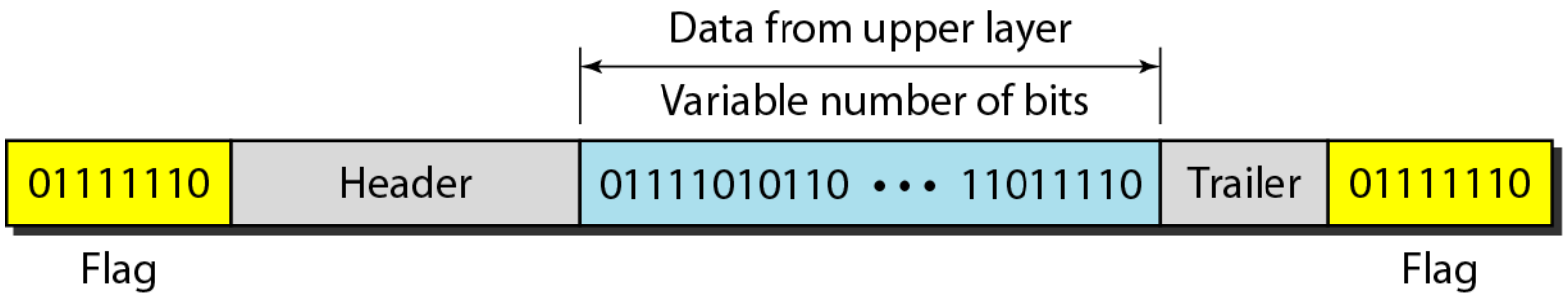


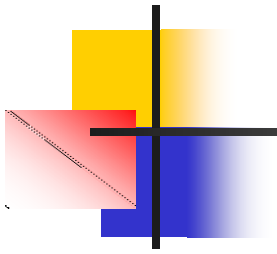


Note

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

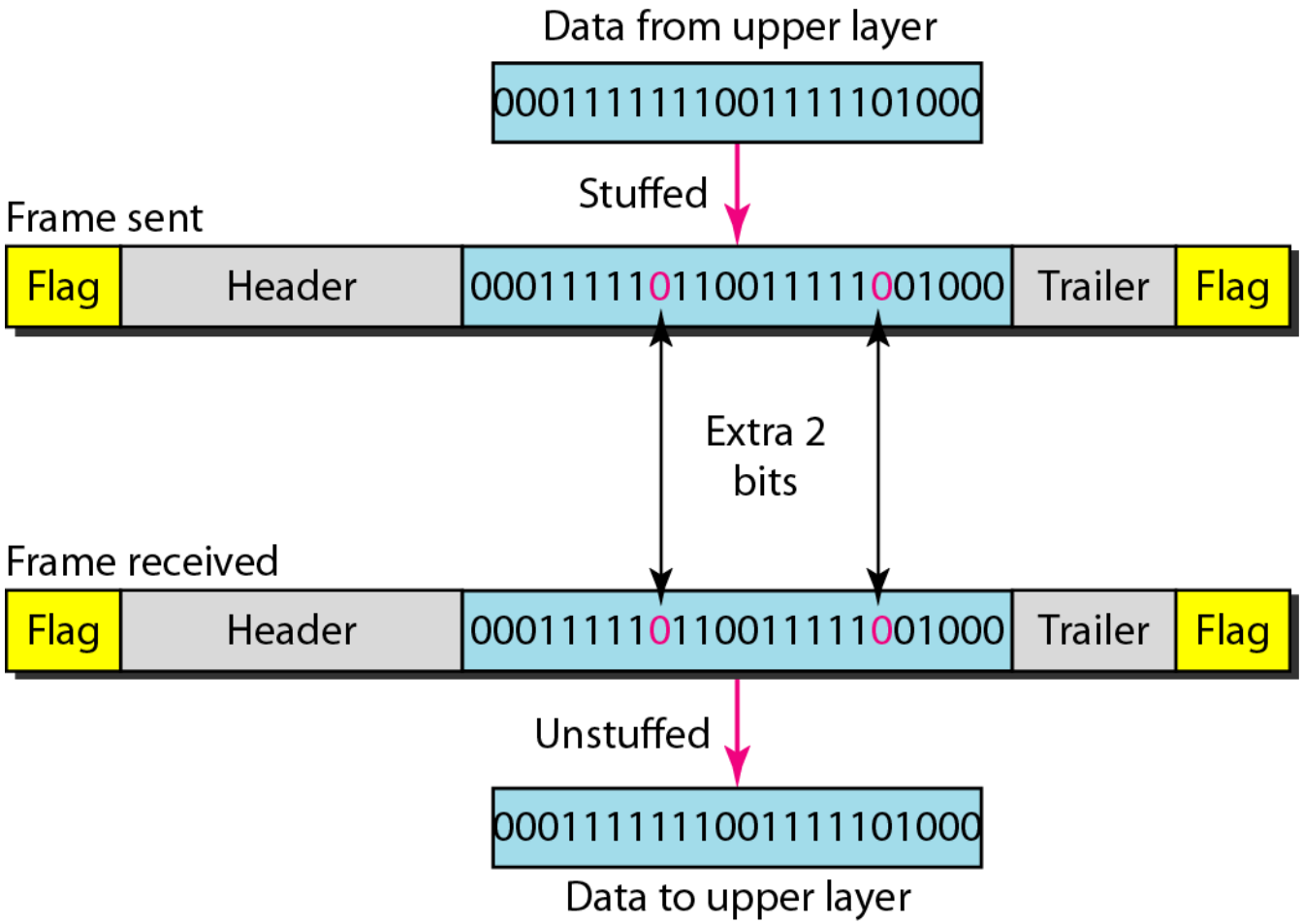




Note

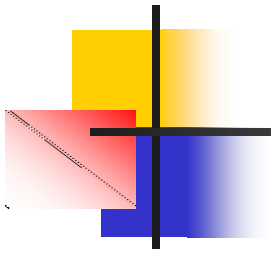
Bit stuffing is the process of adding one extra 0 whenever five consecutive 1s follow a 0 in the data, so that the receiver does not mistake the pattern 0111110 for a flag.

Bit stuffing and unstuffing



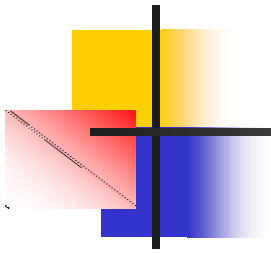
FLOW AND ERROR CONTROL

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



Note

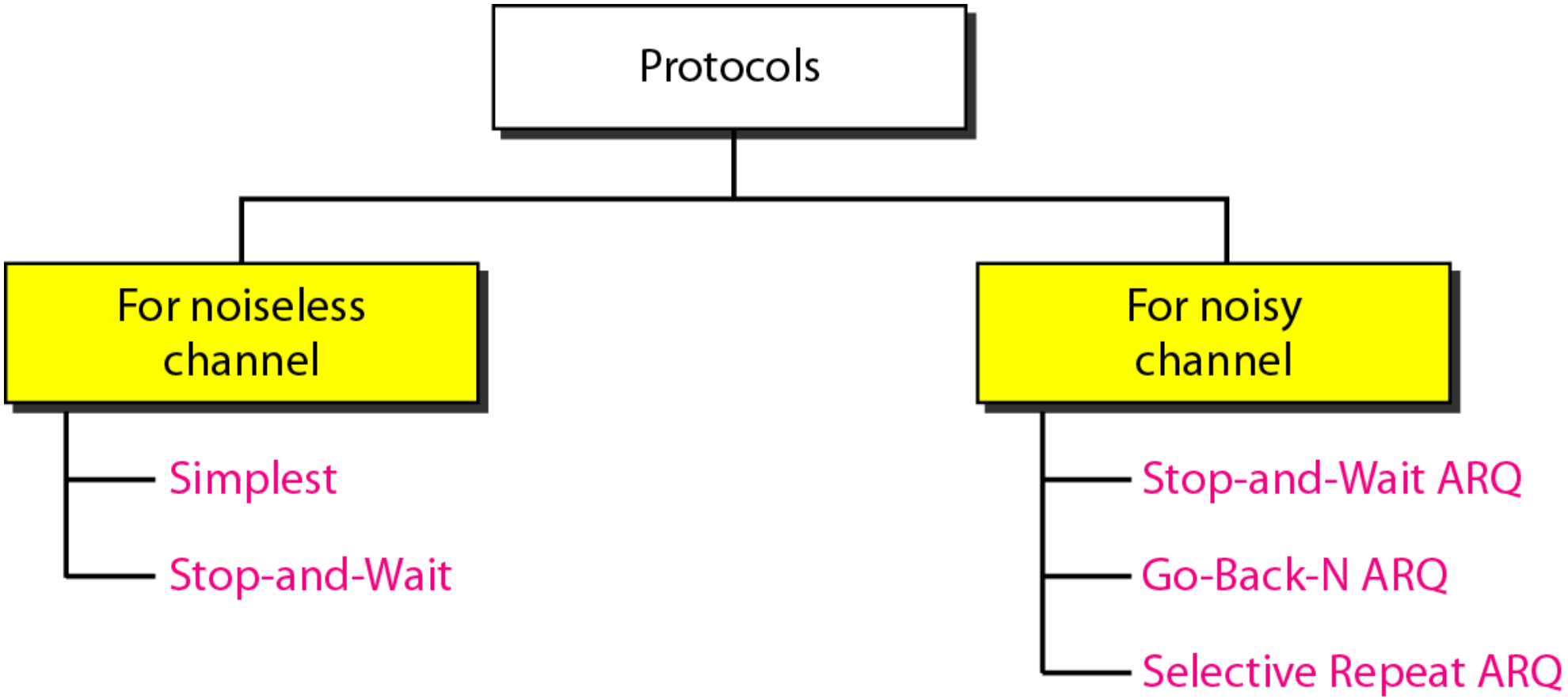
Flow control refers to a set of procedures used to restrict the amount of data that the sender can send before waiting for acknowledgment.



Note

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

Taxonomy of protocols

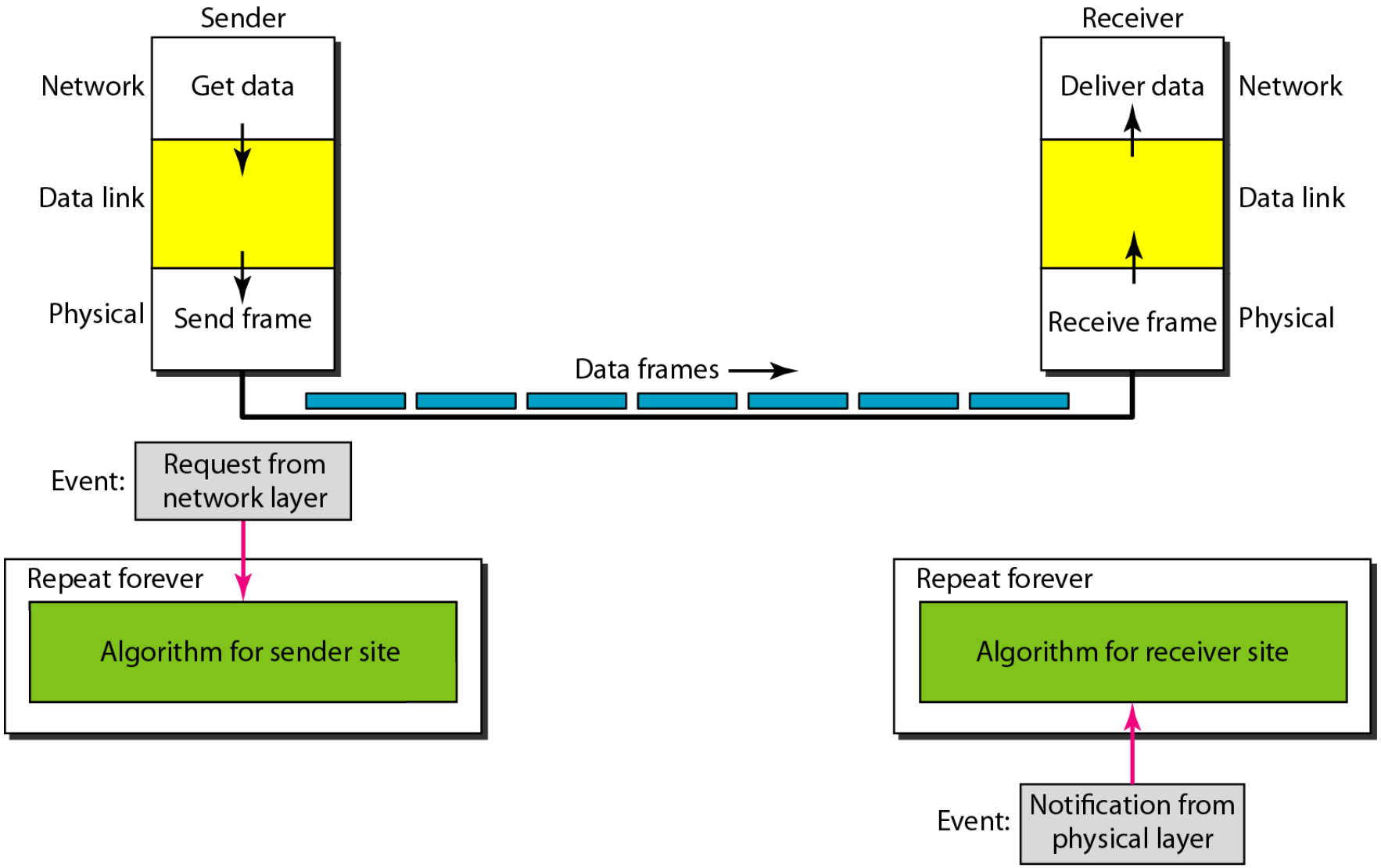


NOISELESS CHANNELS

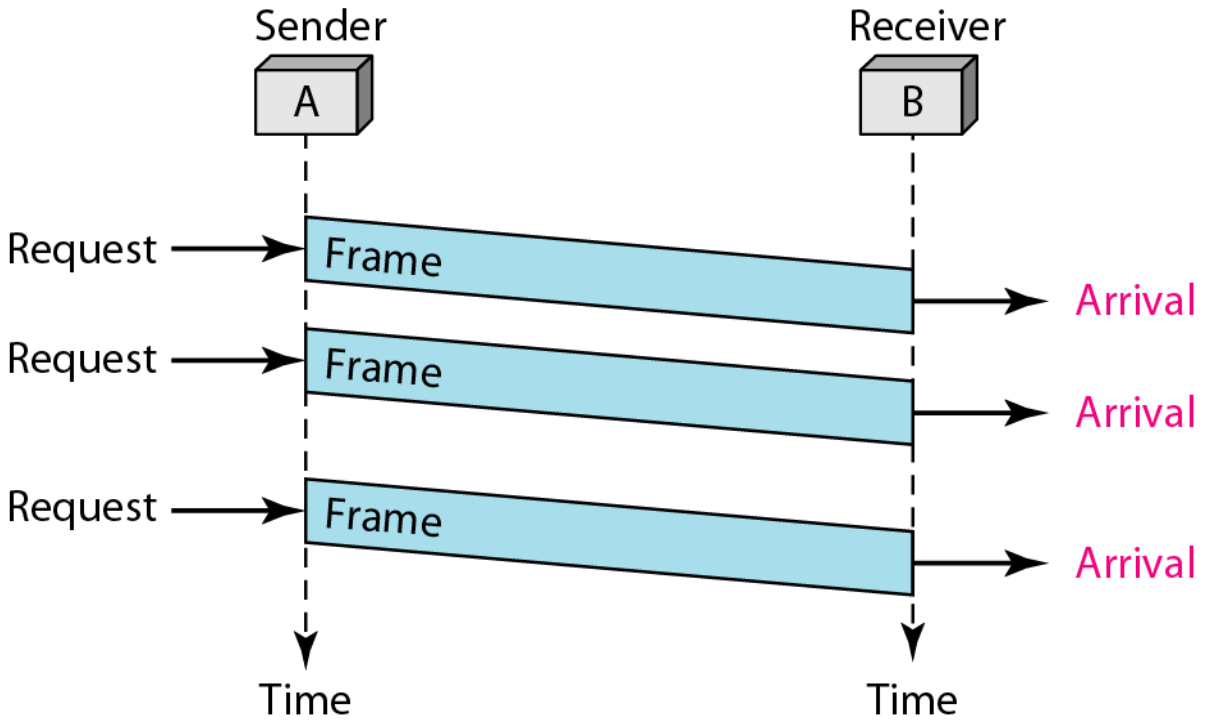
Let us first assume we have an ideal channel in which no frames are lost, duplicated, or corrupted. We introduce two protocols for this type of channel.

Simplest Protocol
Stop-and-Wait Protocol

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



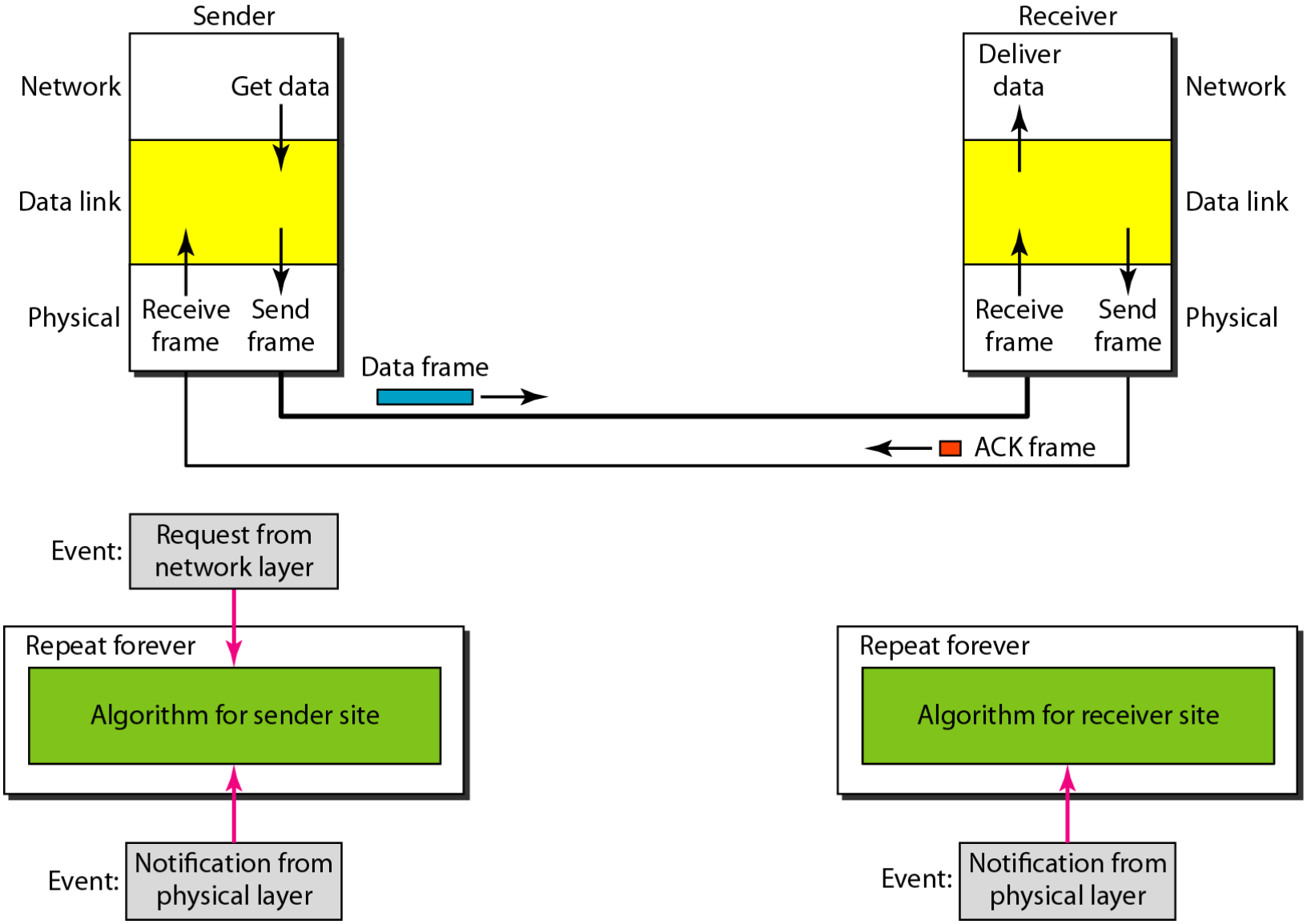
Flow diagram



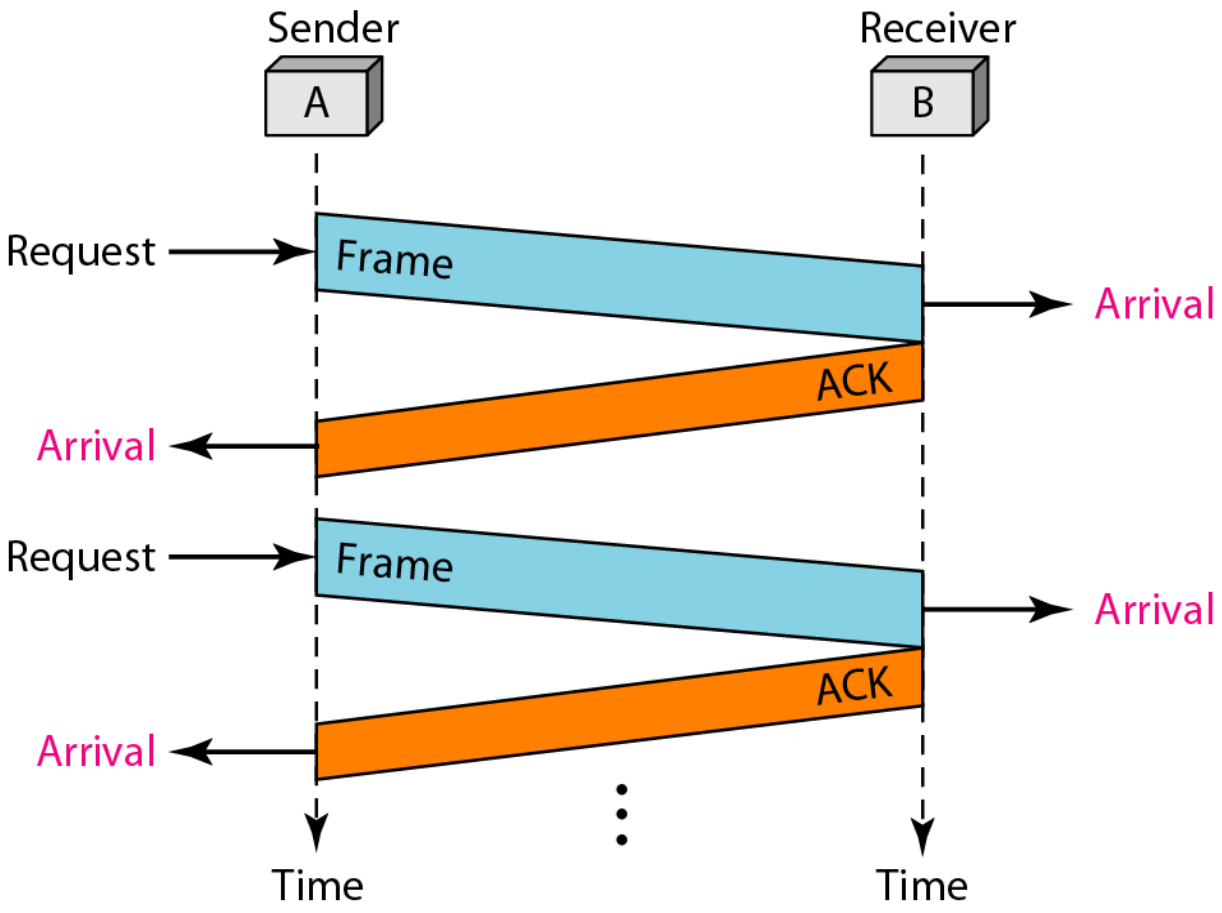
Stop-and-Wait Protocol

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

Design of Stop-and-Wait Protocol



Flow diagram



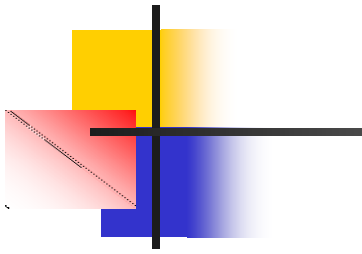
NOISY CHANNELS

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.

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.



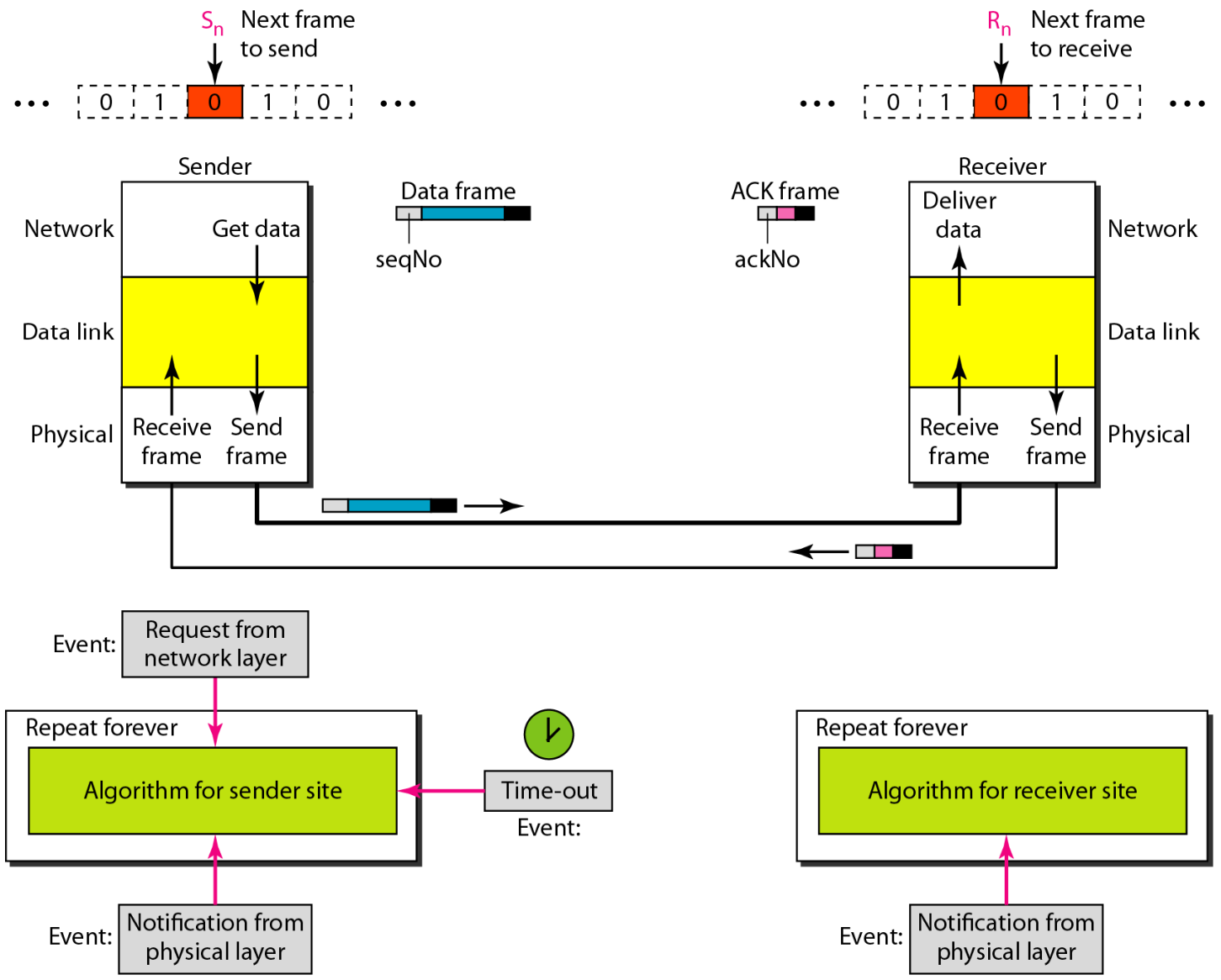
Note

In Stop-and-Wait ARQ, we use sequence numbers to number the frames. The sequence numbers are based on modulo-2 arithmetic.

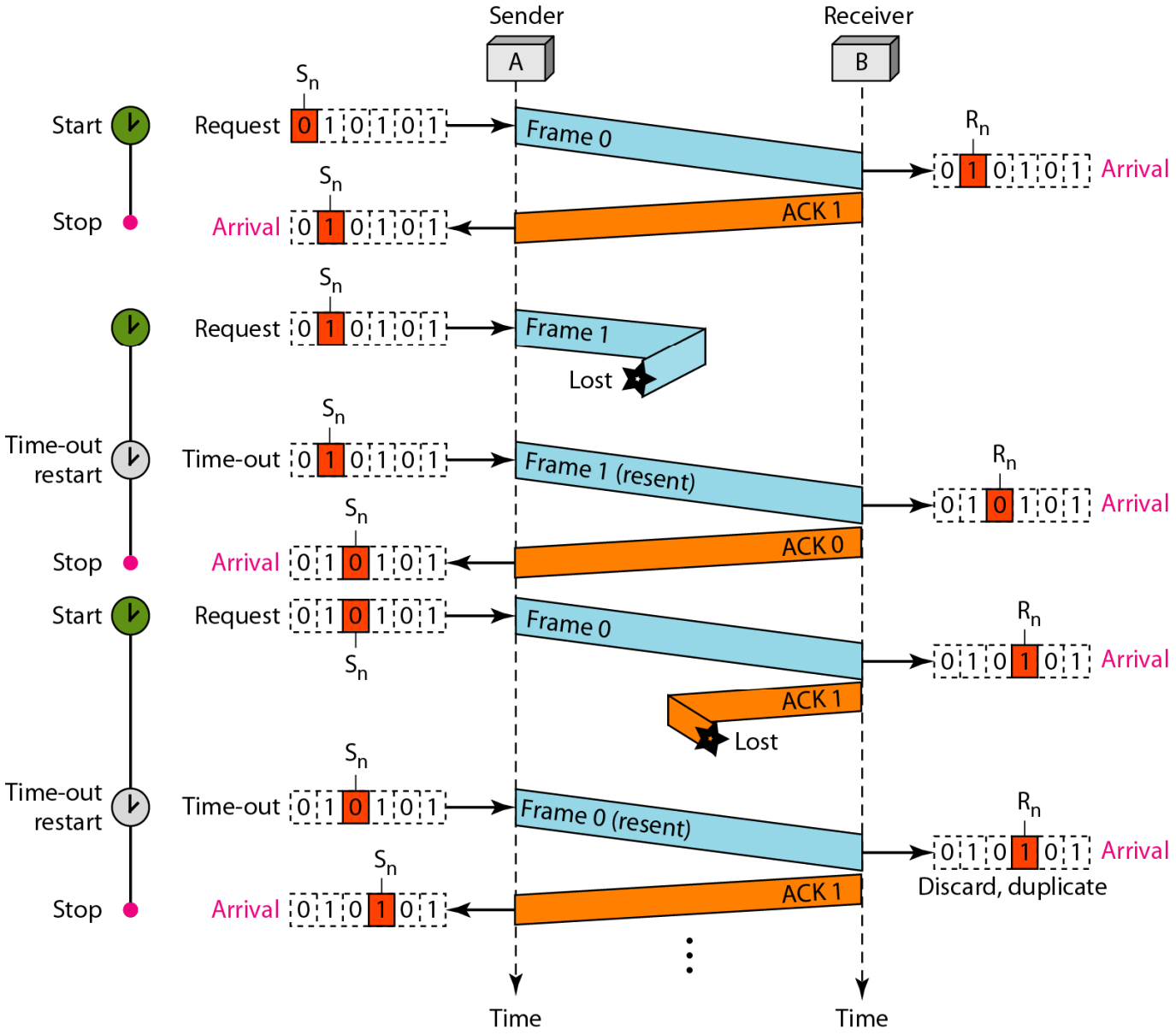
Note

In Stop-and-Wait ARQ, the acknowledgment number always announces in modulo-2 arithmetic the sequence number of the next frame expected.

Design of the Stop-and-Wait ARQ Protocol



Flow diagram



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.

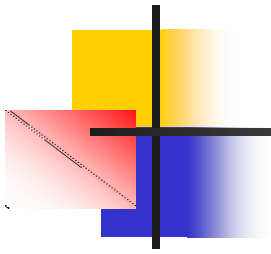
Pipelining

- 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.



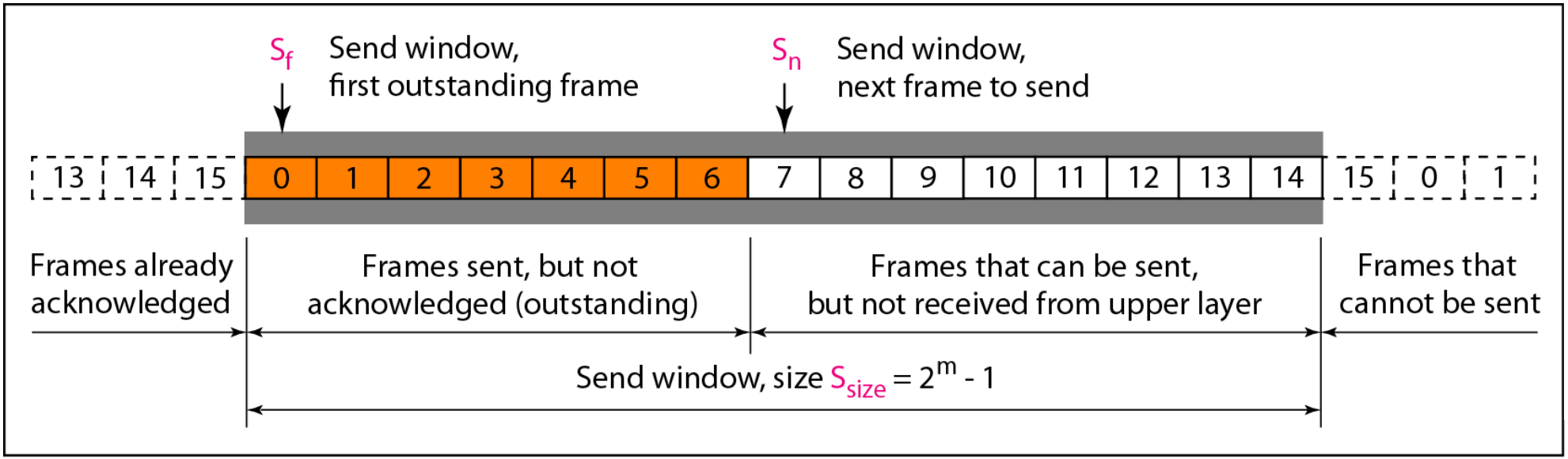
Note

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.

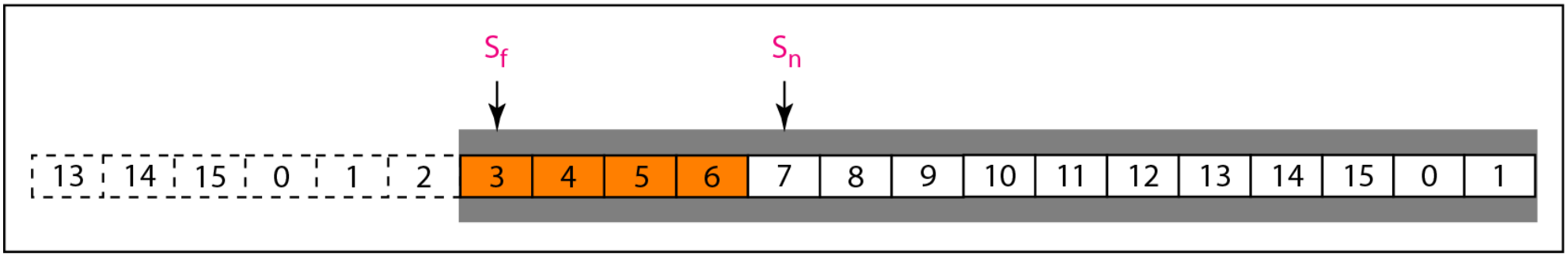
Sliding Window

- 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.

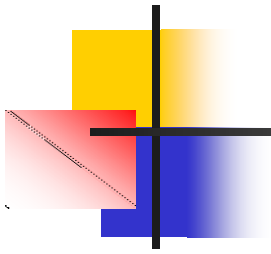
Send window for Go-Back-N ARQ



a. Send window before sliding



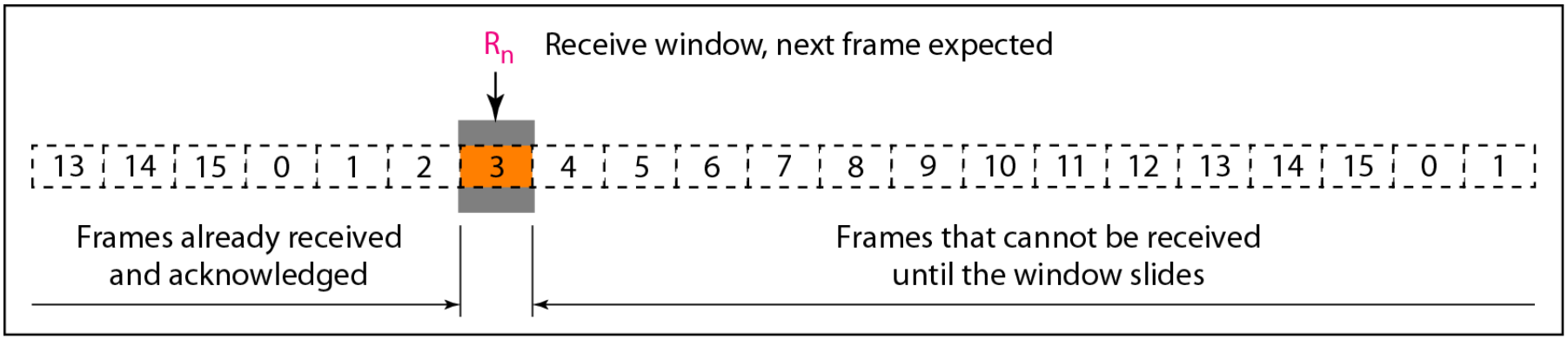
b. Send window after sliding



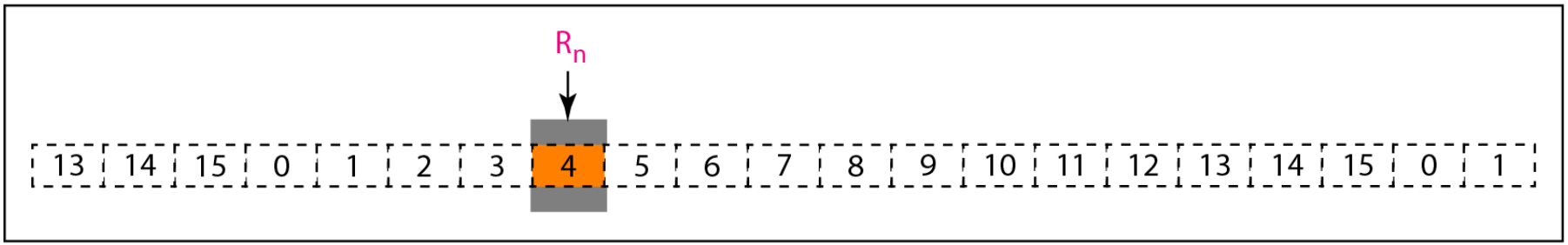
Note

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

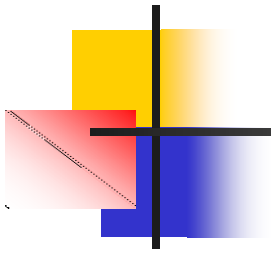
Receive window for Go-Back-N ARQ



a. Receive window



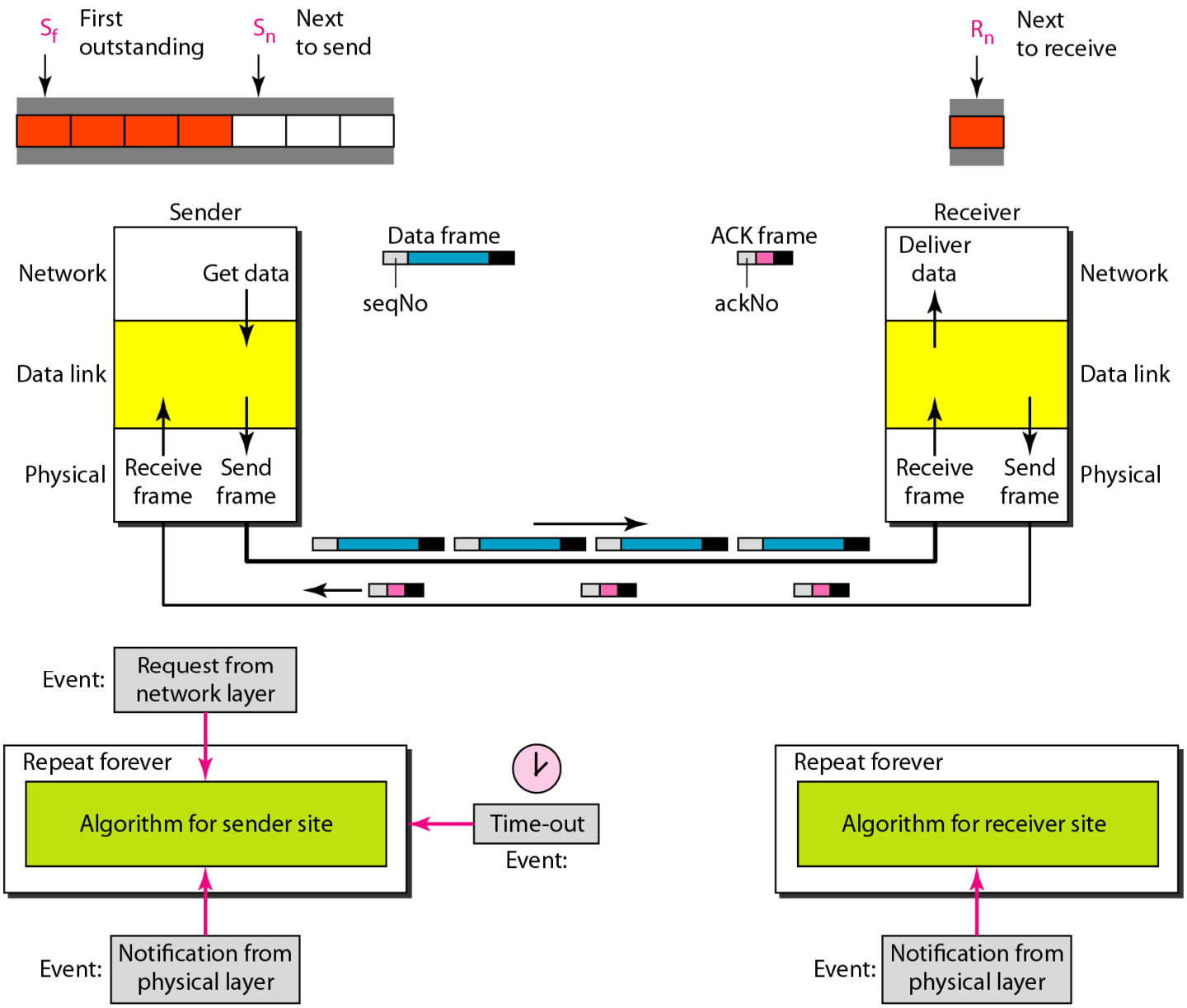
b. Window after sliding



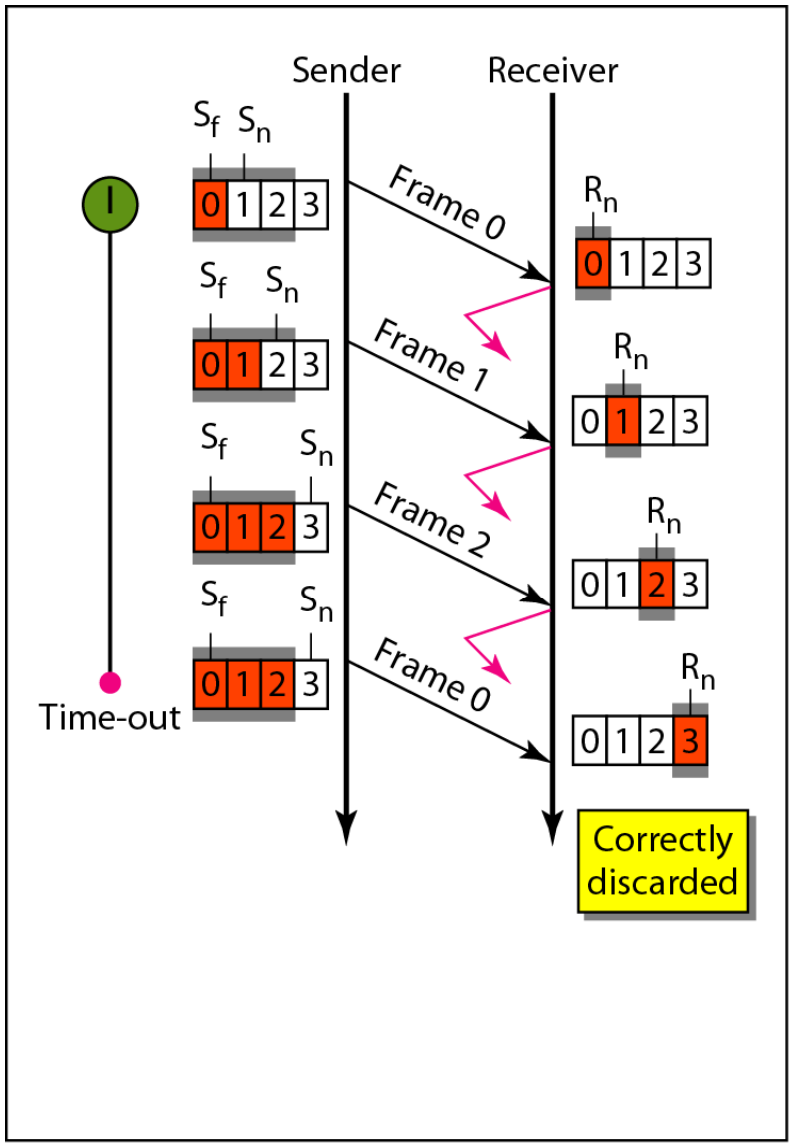
Note

The window slides when a correct frame has arrived; sliding occurs one slot at a time.

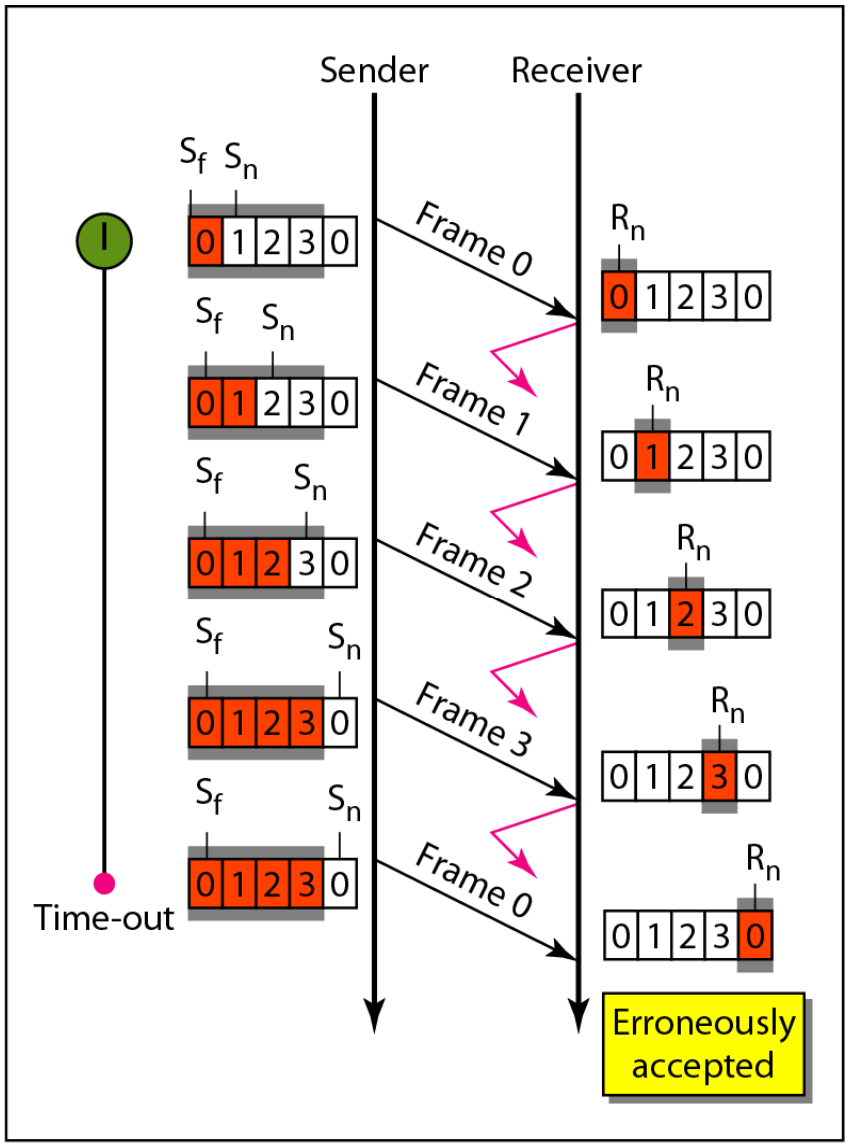
Design of Go-Back-N ARQ



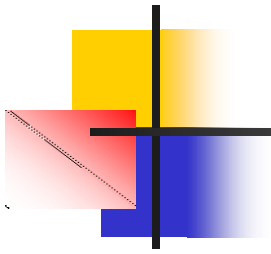
Window size for Go-Back-N ARQ



a. Window size < 2^m



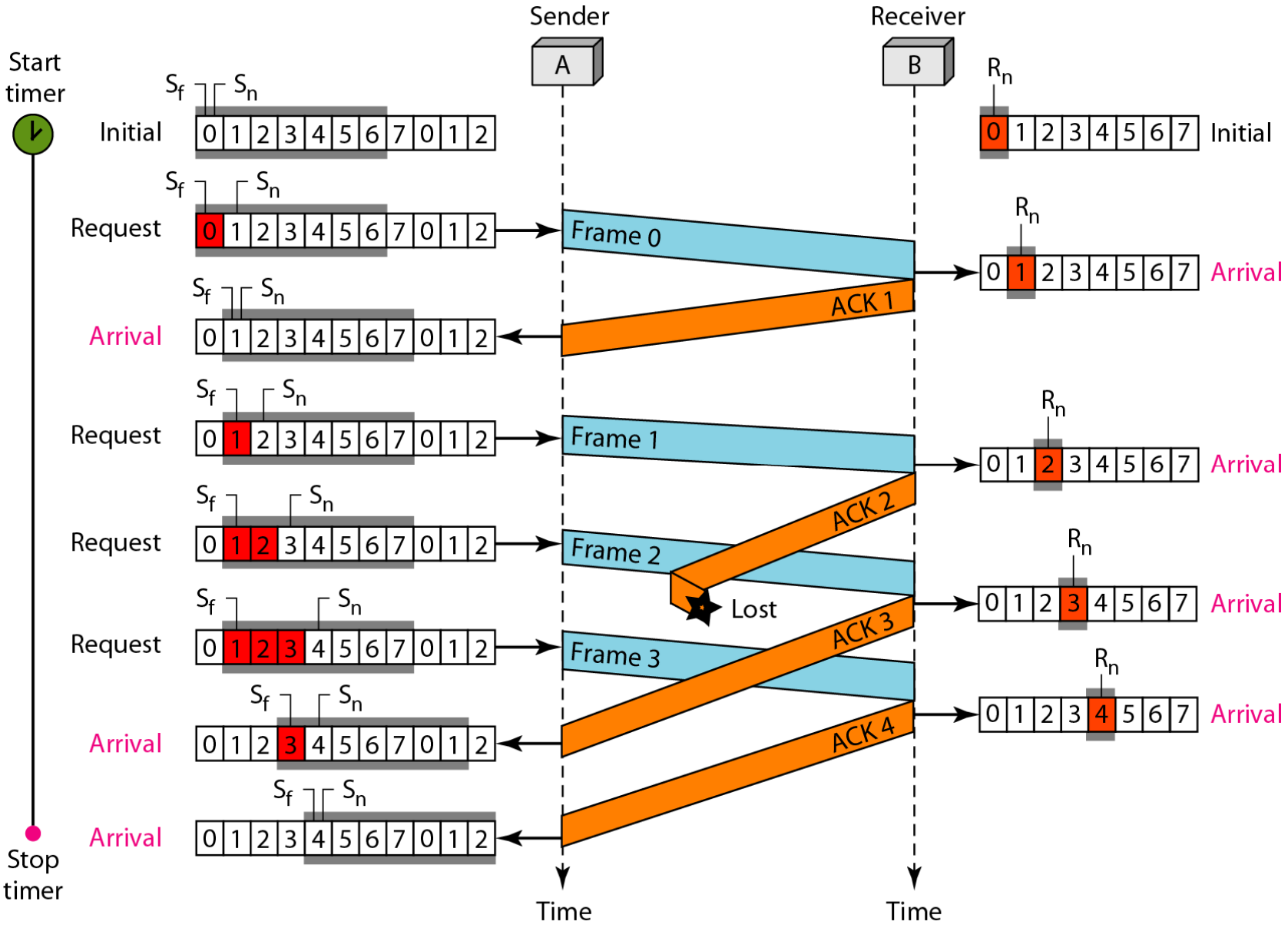
b. Window size = 2^m



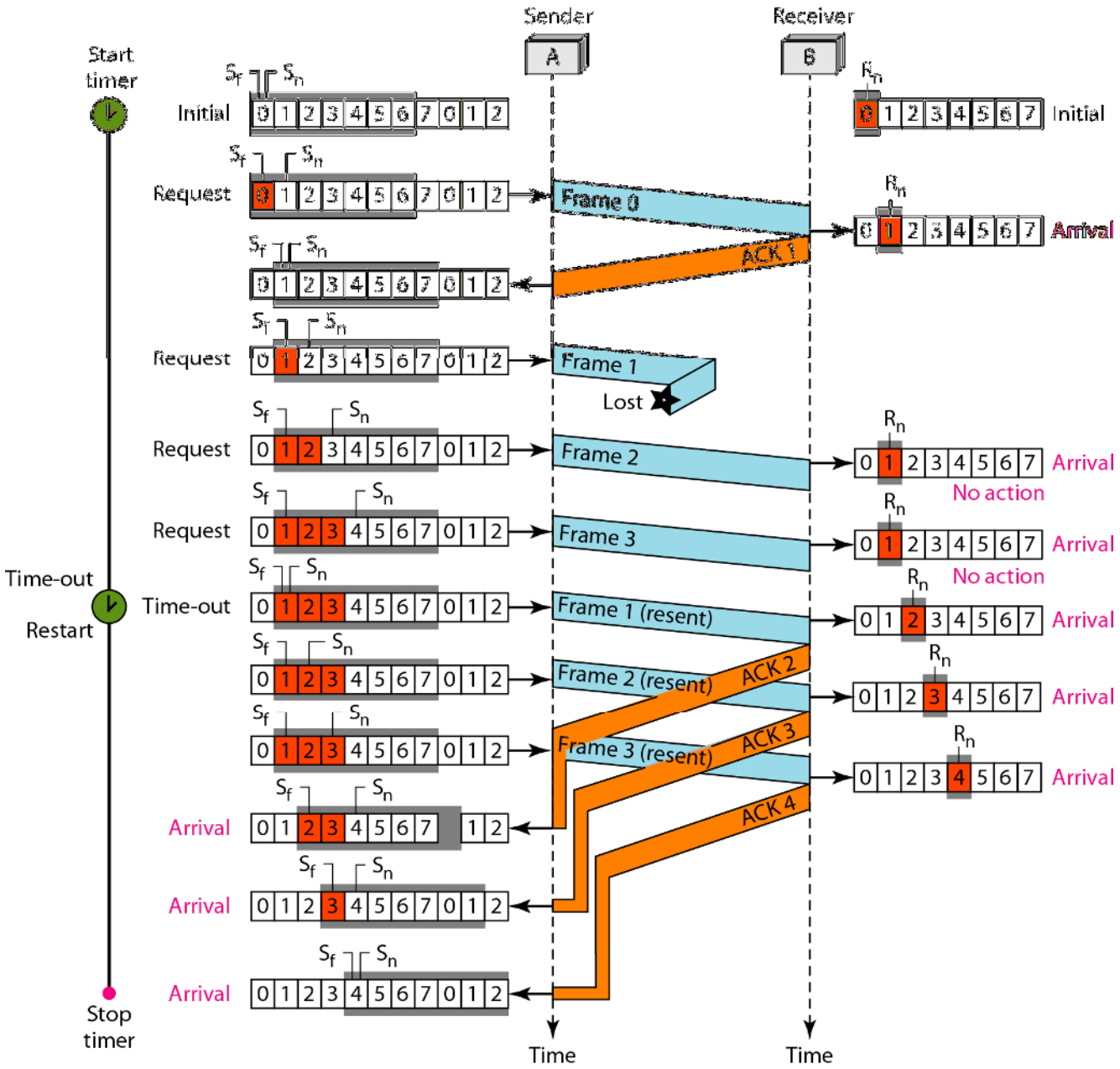
Note

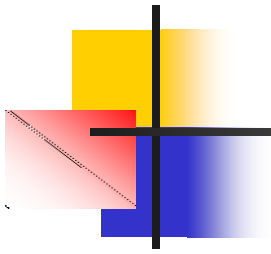
In Go-Back-N ARQ, the size of the send window must be less than 2^m; the size of the receiver window is always 1.

Flow diagram



Flow diagram

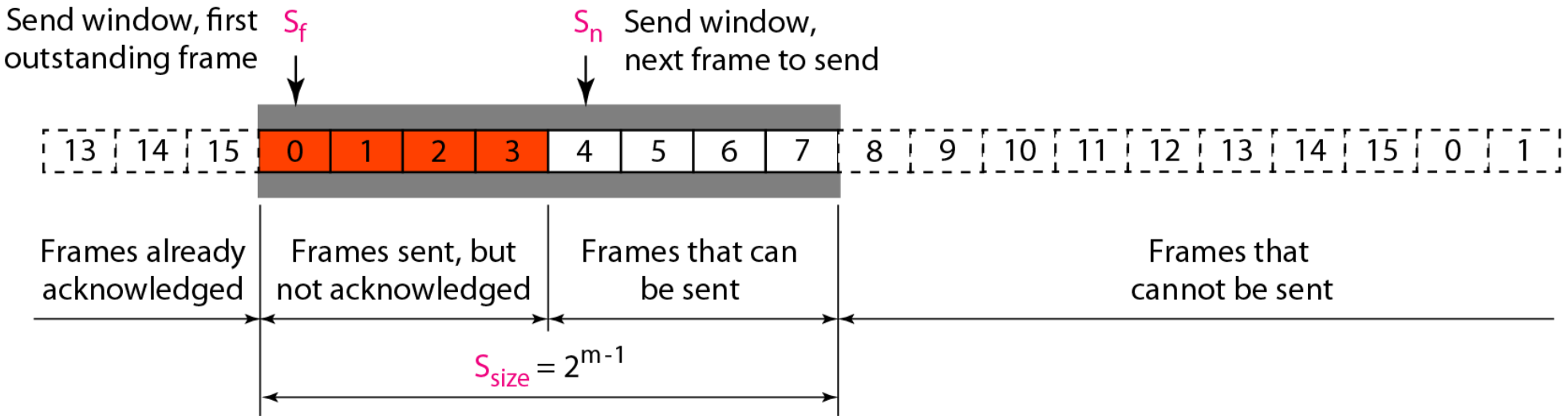




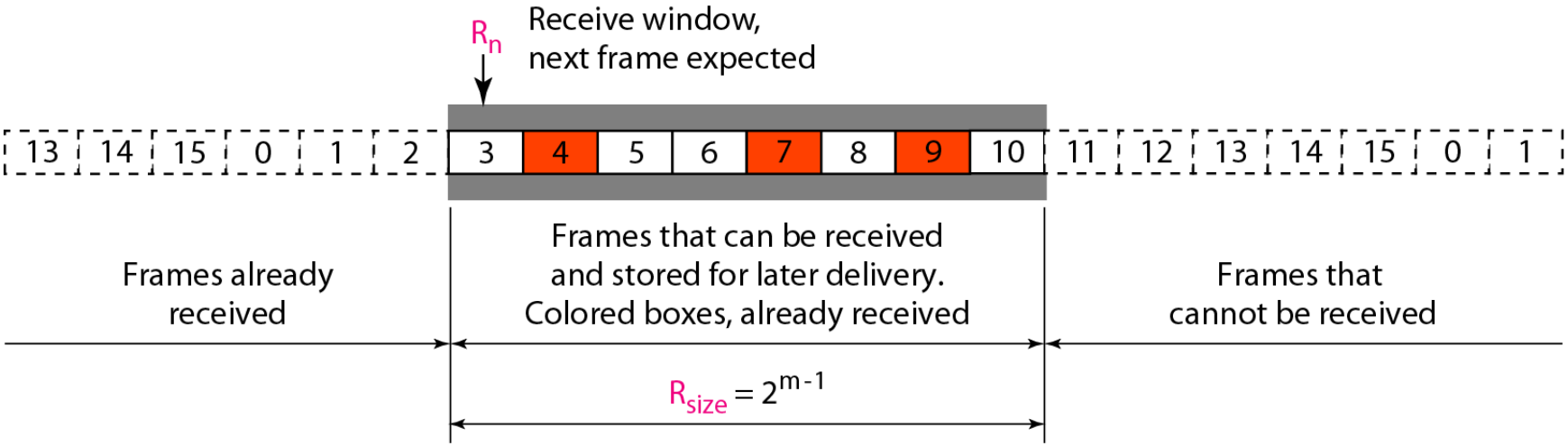
Note

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

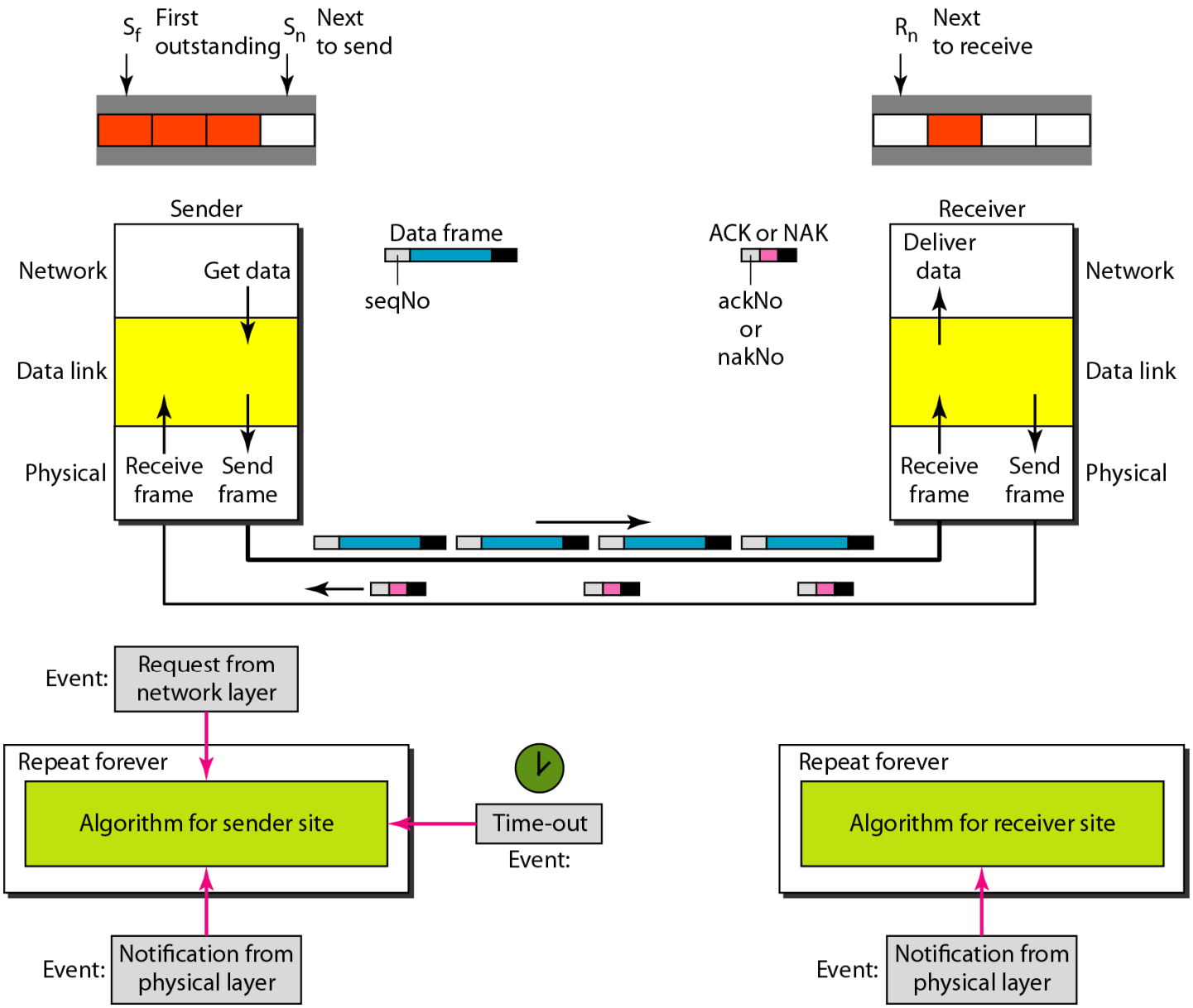
Send window for Selective Repeat ARQ



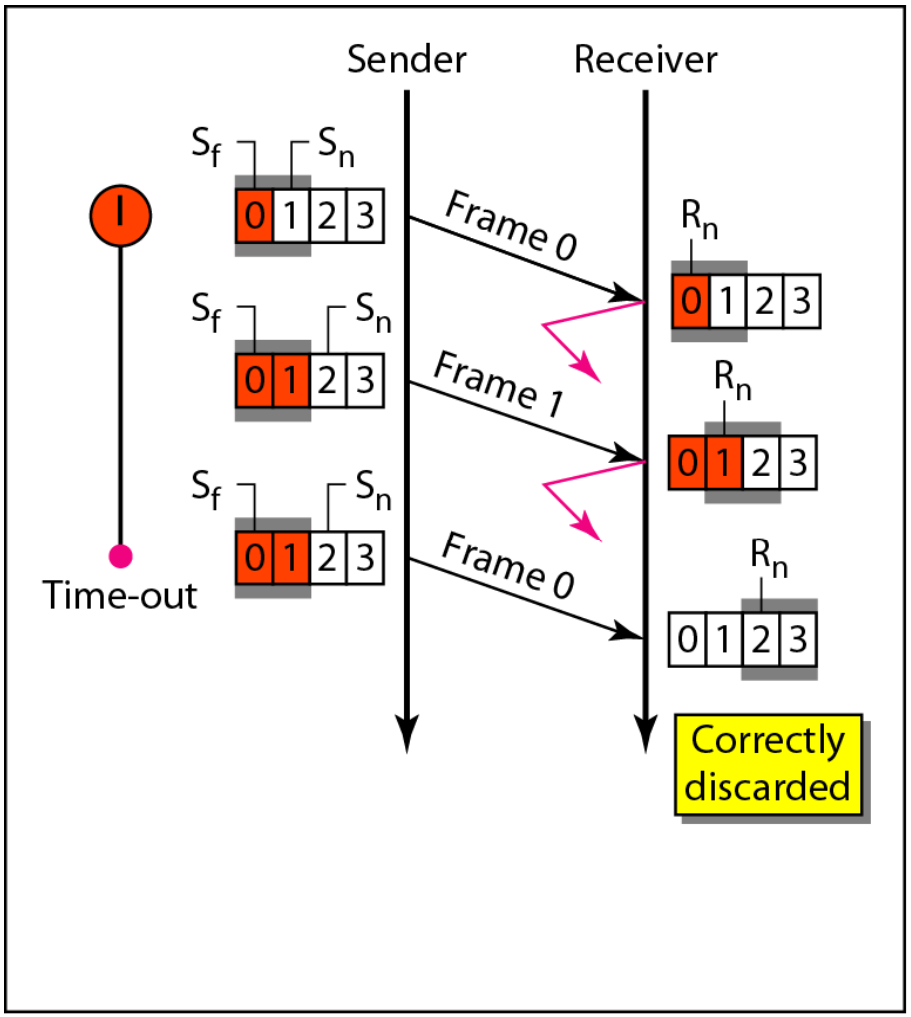
Receive window for Selective Repeat ARQ



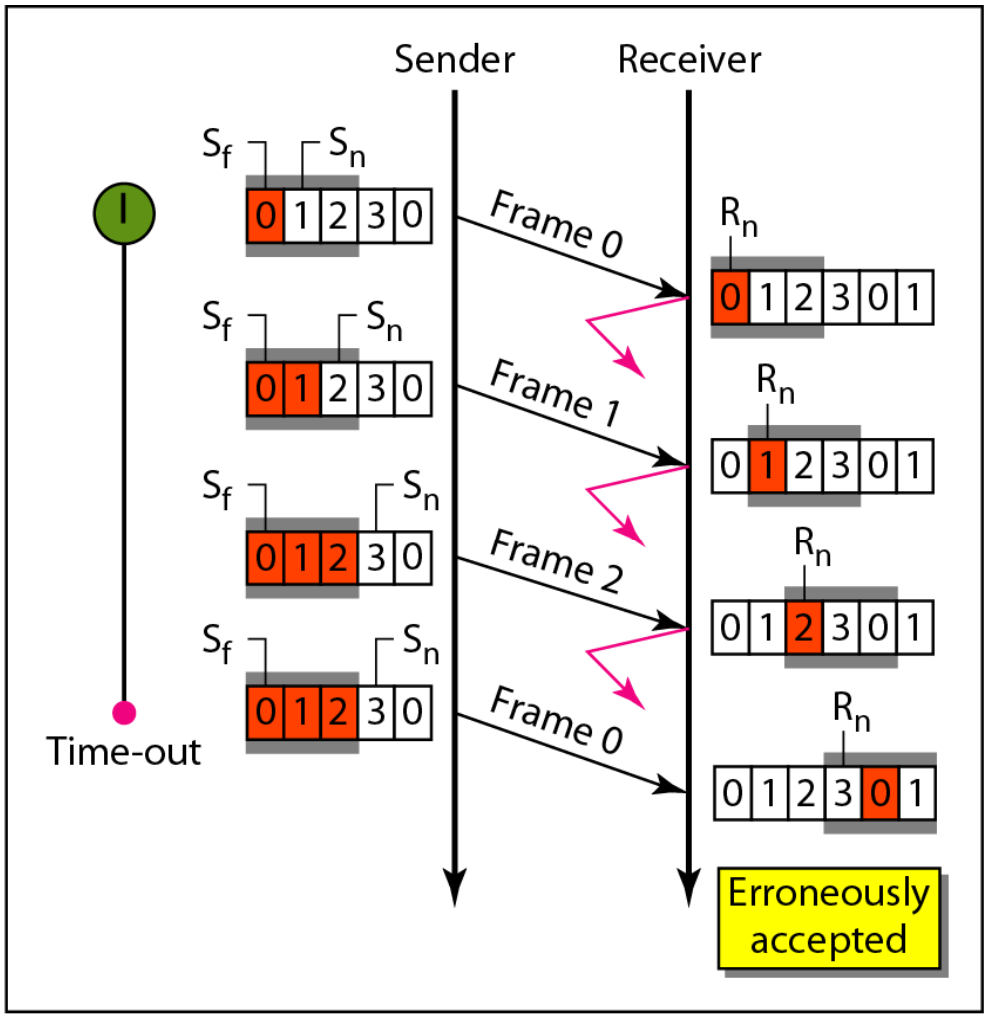
Design of Selective Repeat ARQ



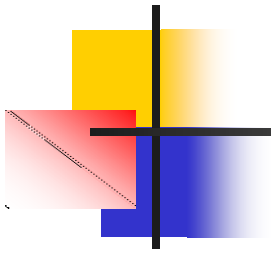
Selective Repeat ARQ, window size



a. Window size = 2^{m-1}



b. 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.

Flow diagram