Data Link Control and Protocols

Data Link Control

Framing

Flow Control

Error Control

Protocols(software)

Framing

- Data bits packed into frames
- separates a message from other by adding sender and destination address.
- Can be fixed size (e.g. ATM) or
- variable size framing (e.g. LAN)
- Start and end of frame need to define
- Character oriented and bit oriented protocol

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.

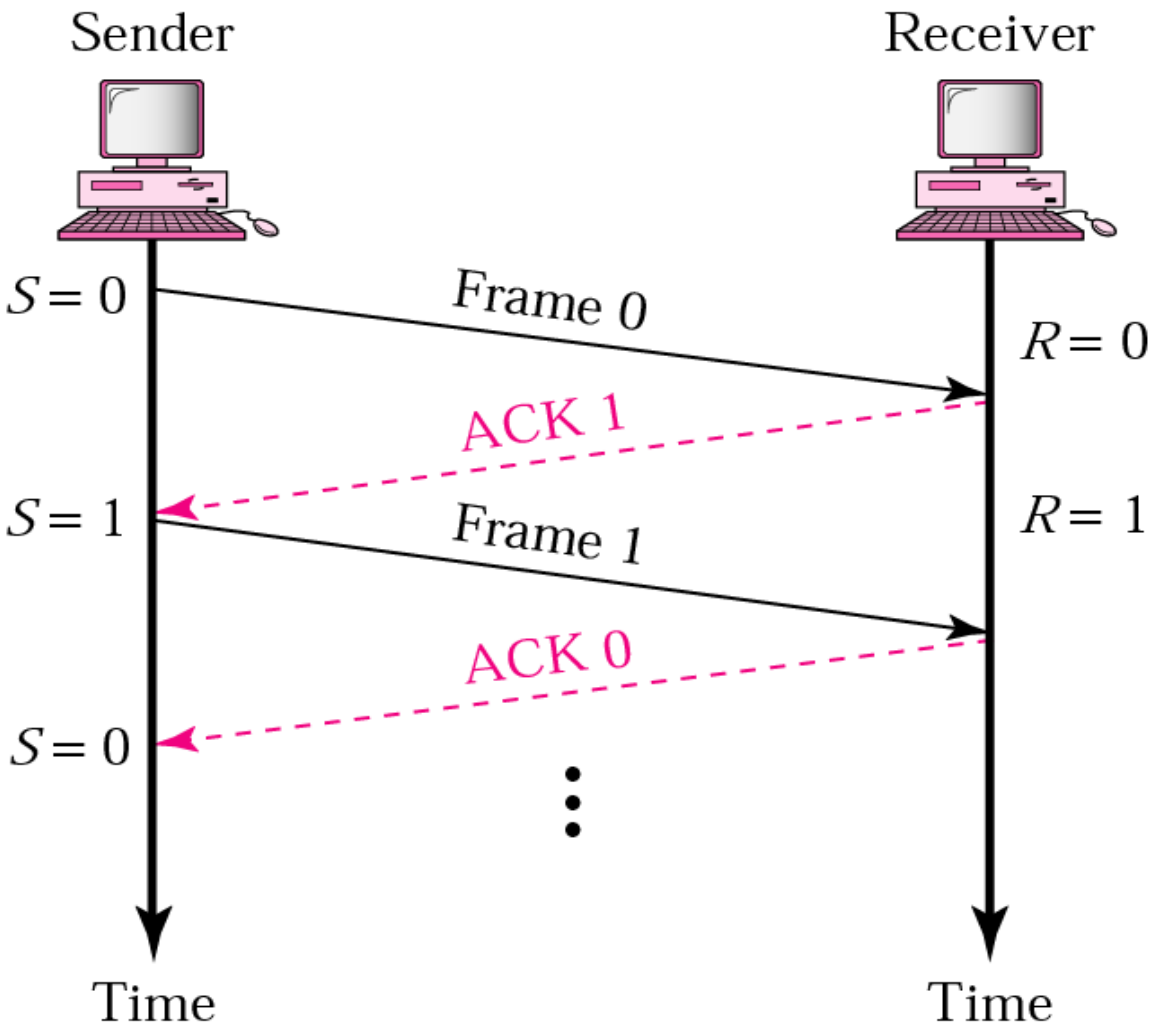
Note:

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

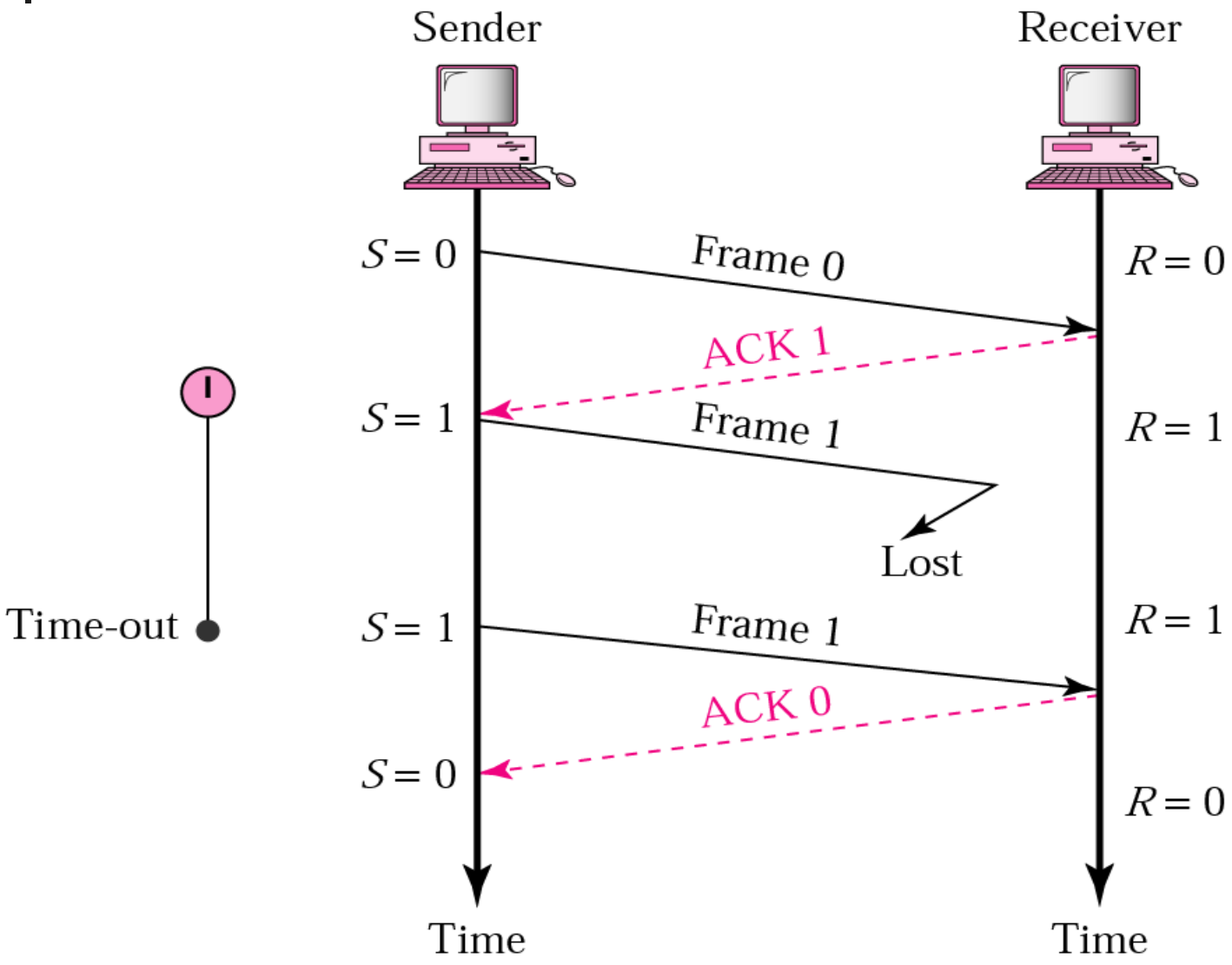
Stop-and-Wait ARQ

Operation

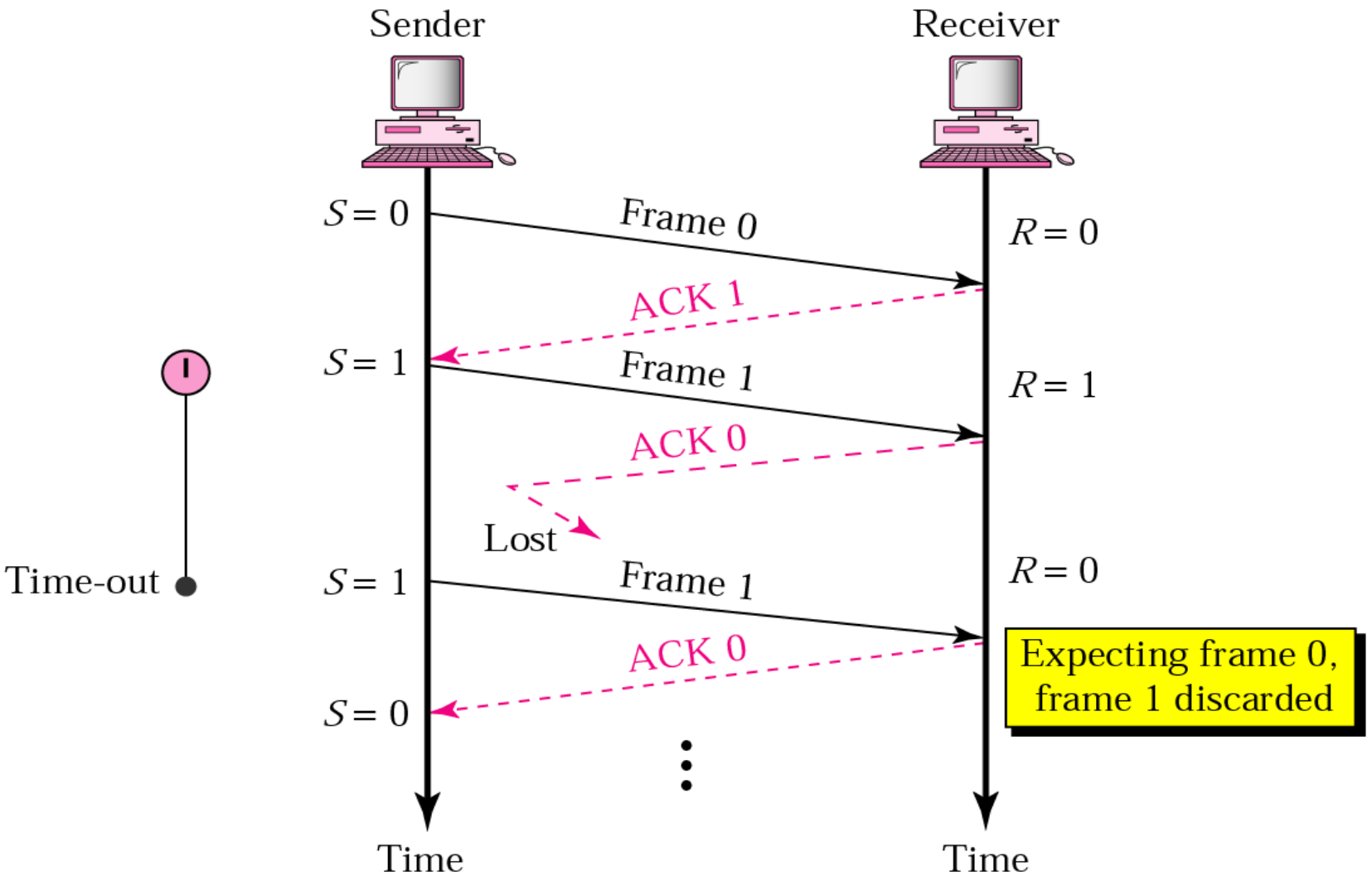
Bidirectional Transmission



11.2 Stop-and-Wait ARQ, lost frame



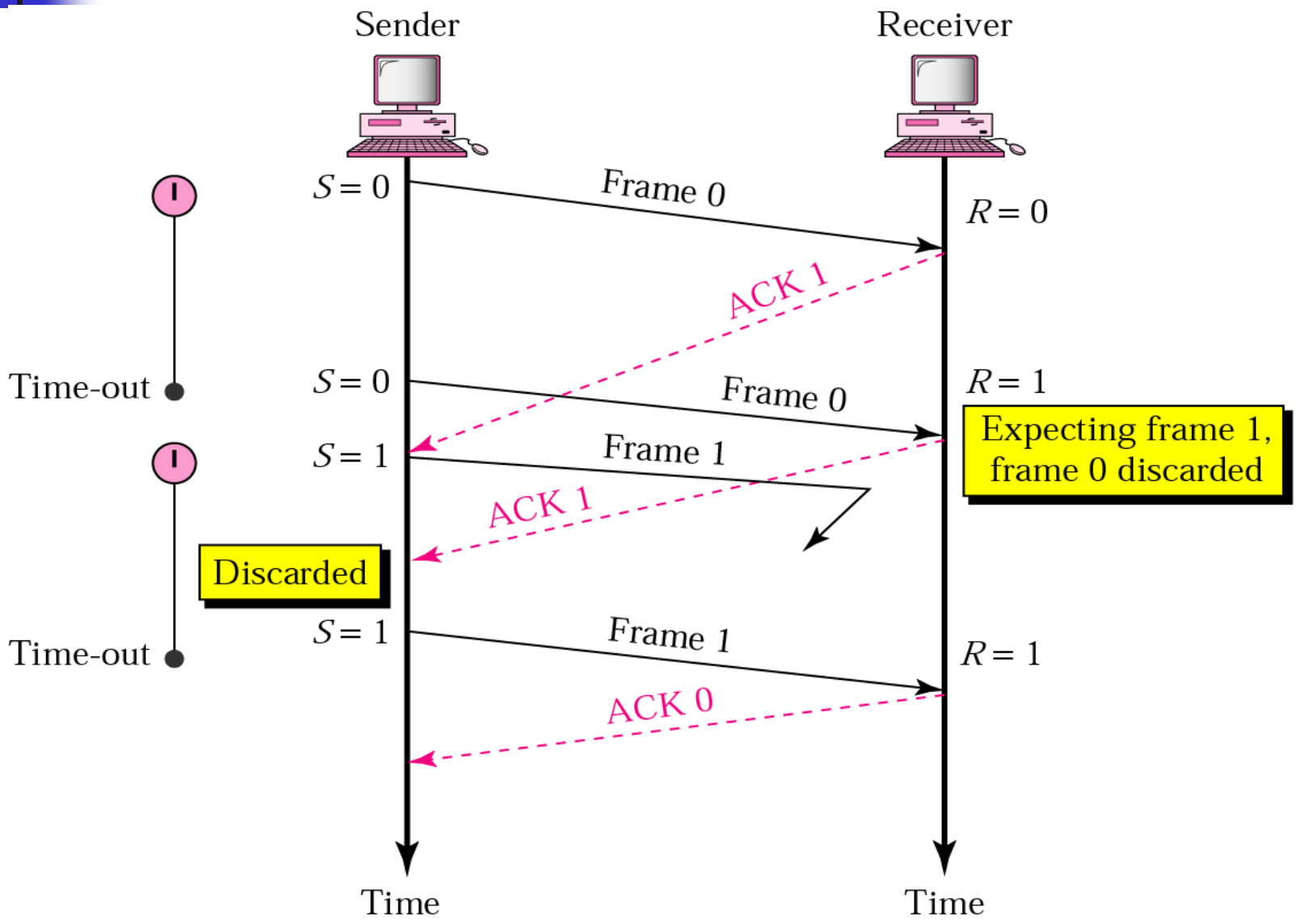
11.3 Stop-and-Wait ARQ, lost ACK frame



Note:

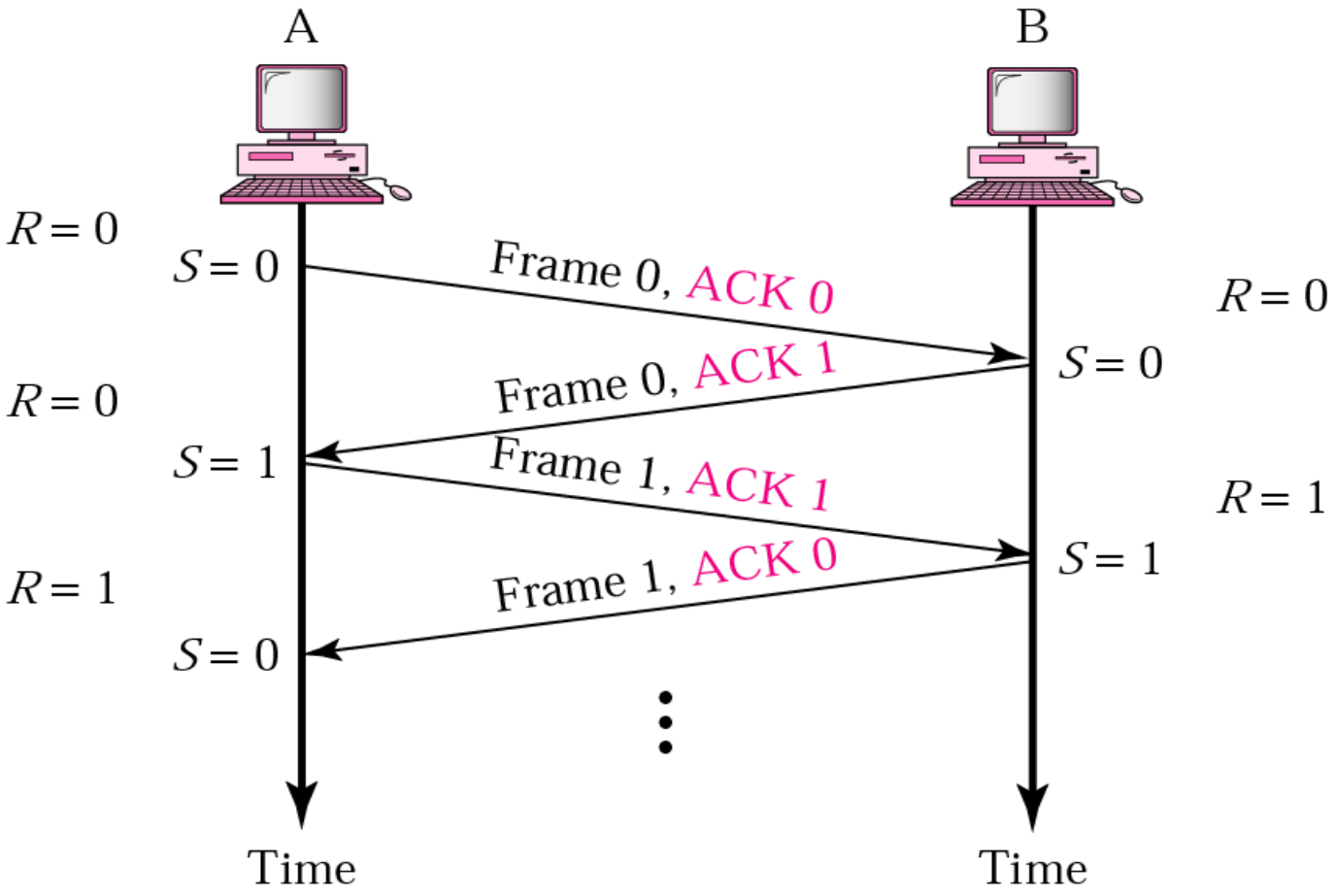
In Stop-and-Wait ARQ, numbering frames prevents the retaining of duplicate frames.

11.4 Stop-and-Wait ARQ, delayed ACK



Note:

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



Go-Back-N ARQ

Sequence Number

Sender and Receiver Sliding Window

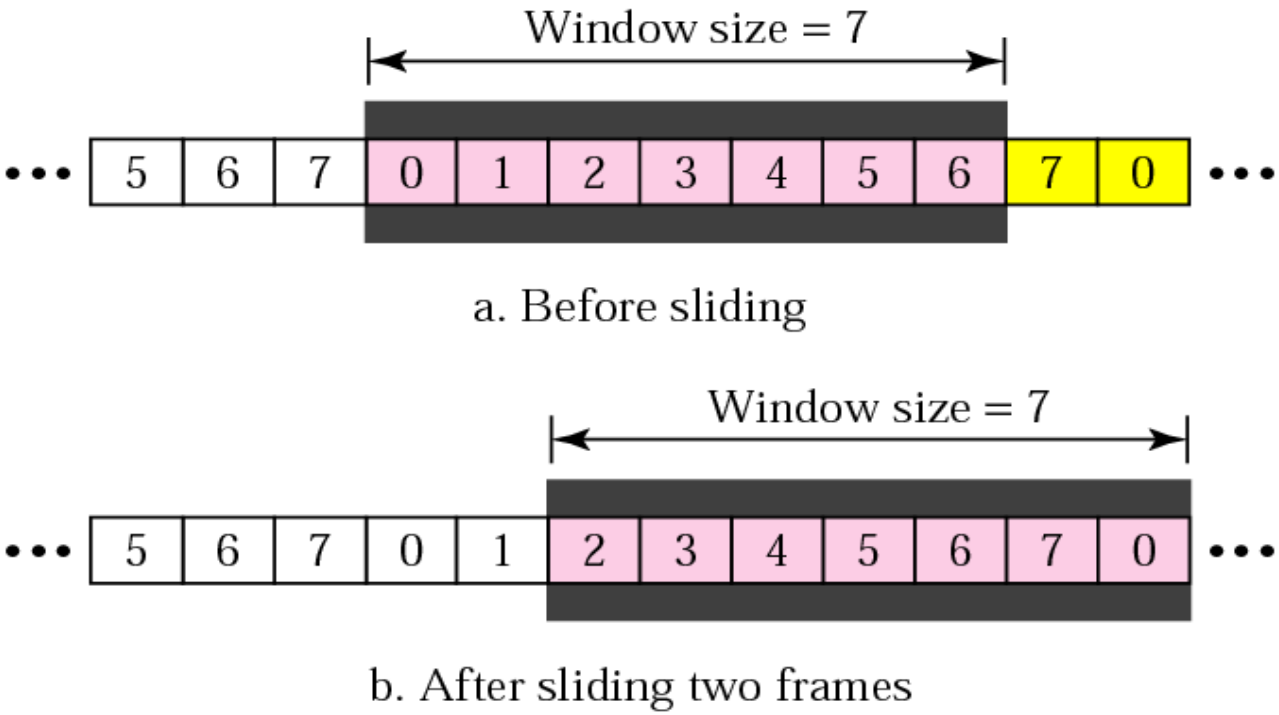
Control Variables and Timers

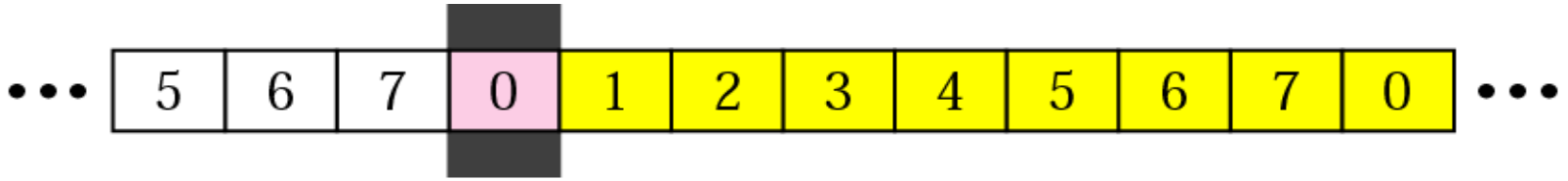
Acknowledgment

Resending Frames

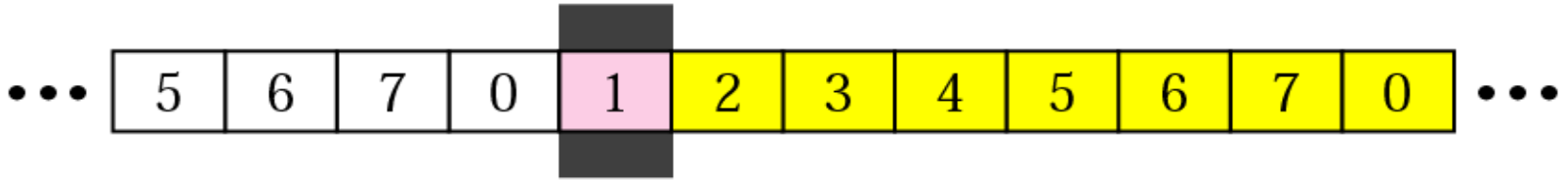
Operation

11.6 Sender sliding window

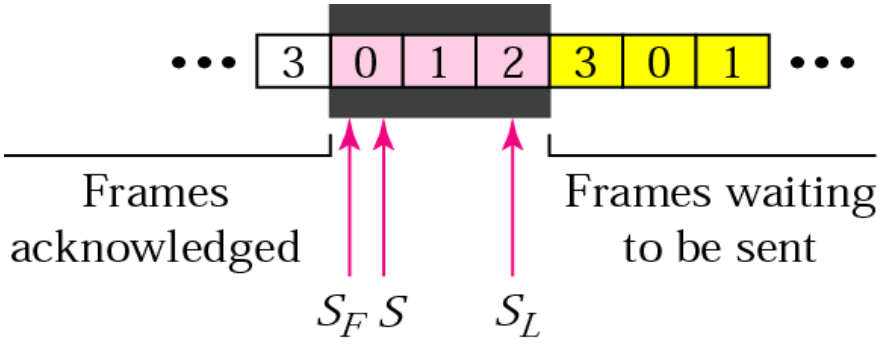




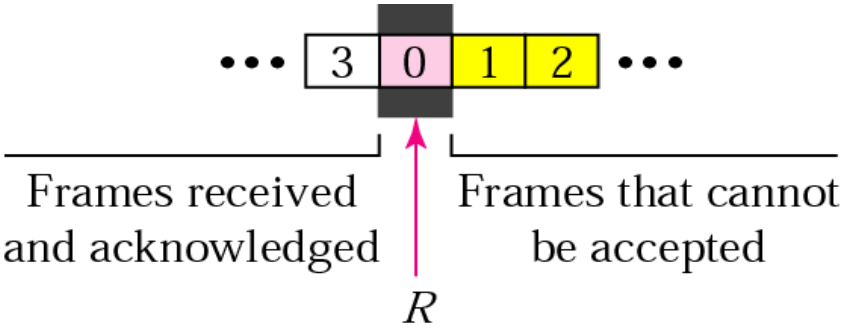
a. Before sliding



b. After sliding

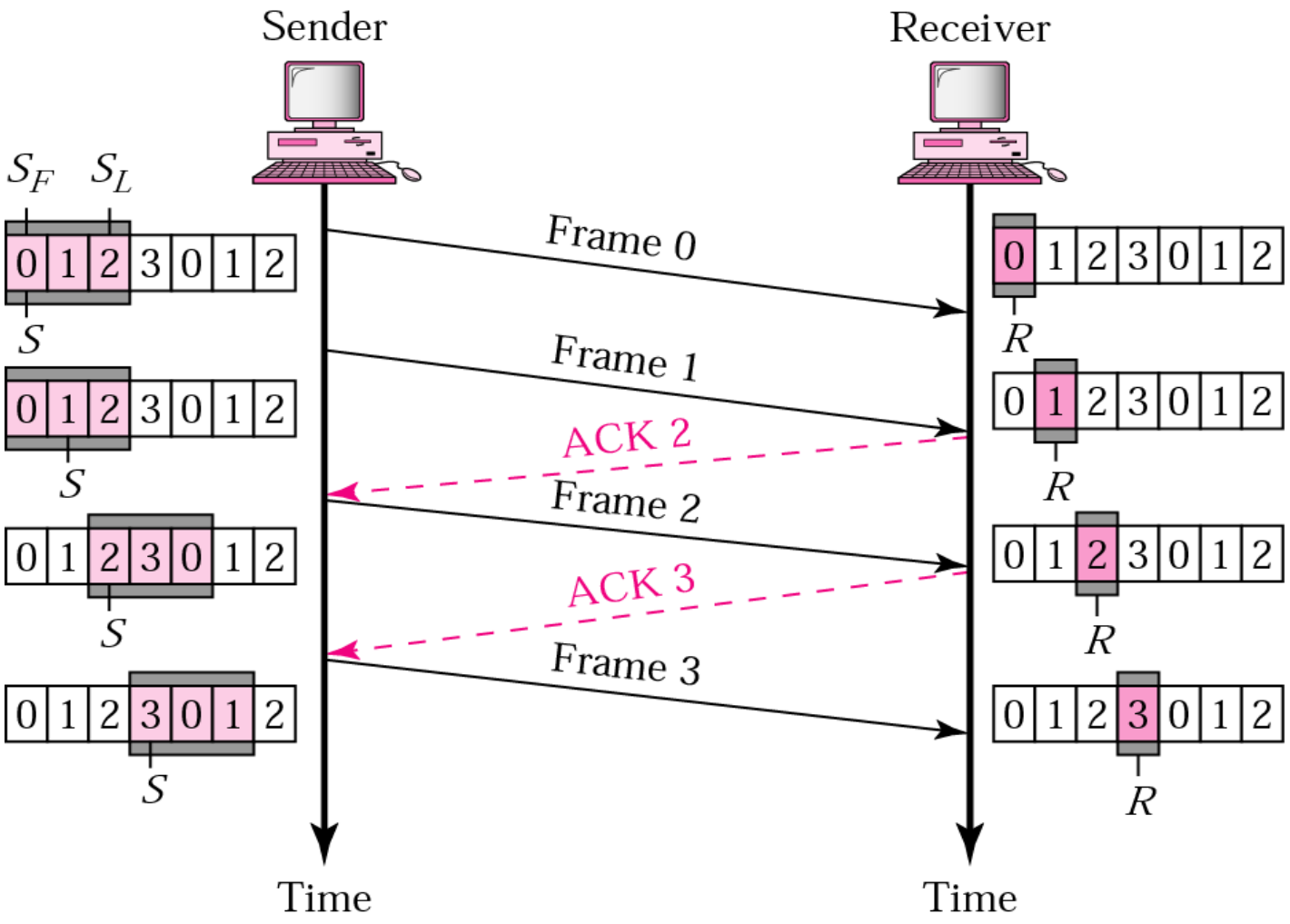


a. Sender window

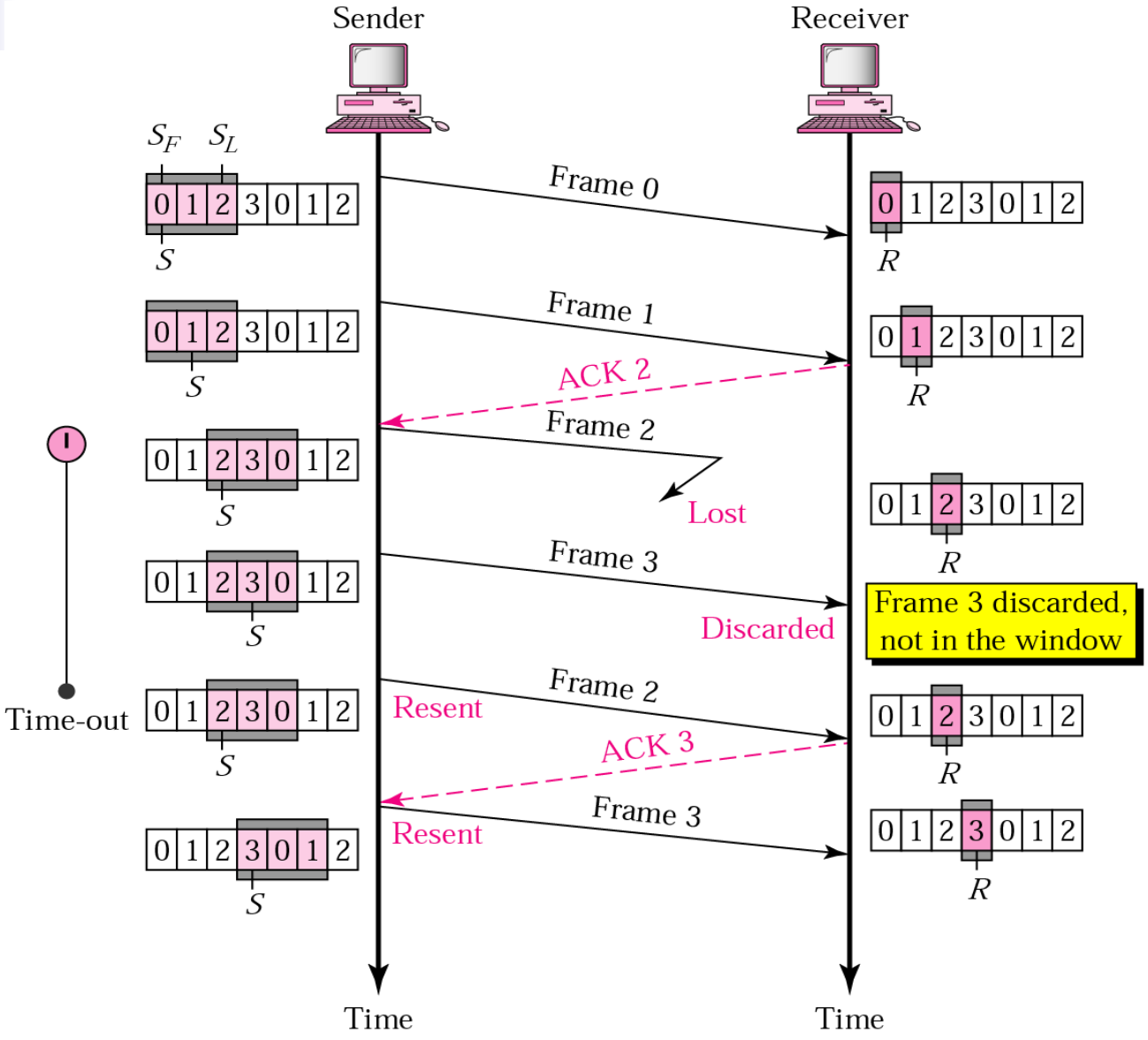


b. Receiver window

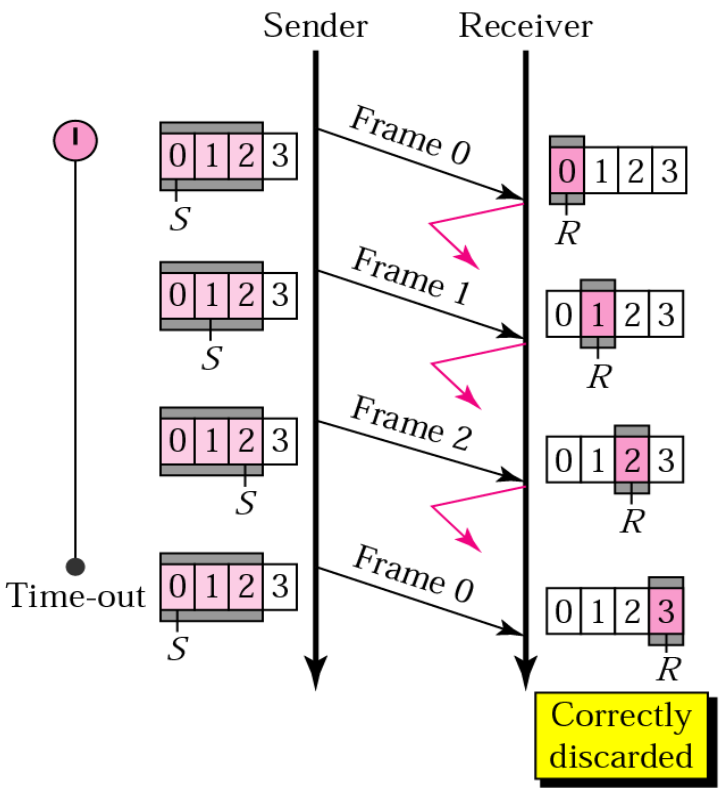
11.9 Go-Back-N ARQ, normal operation



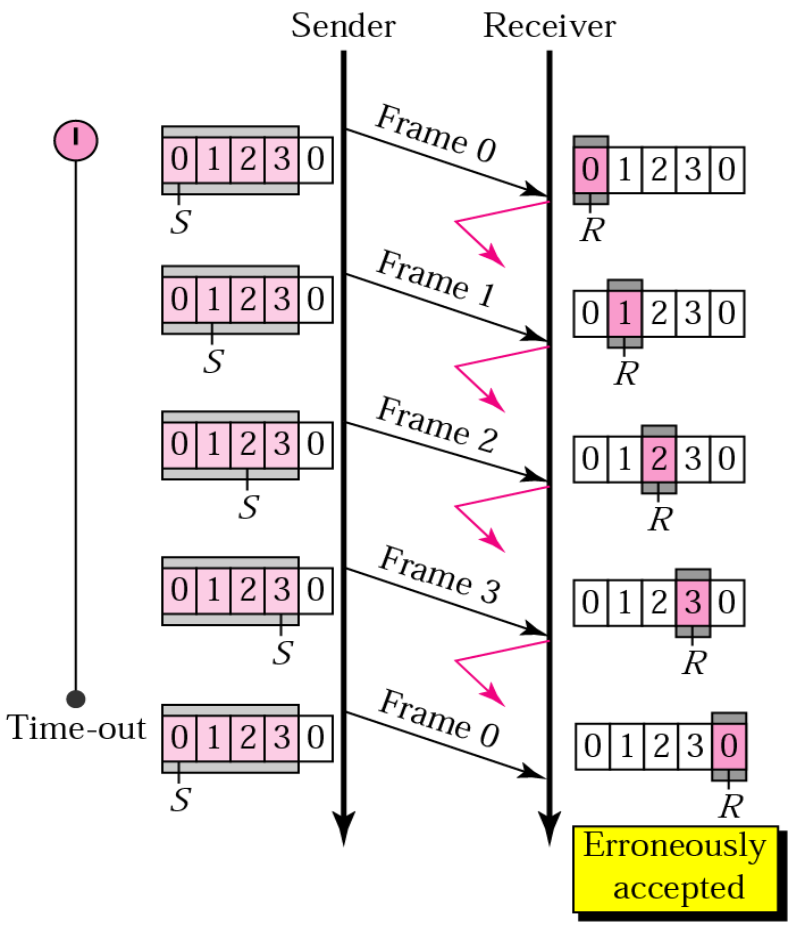
11.10 Go-Back-N ARQ, lost frame



11.11 Go-Back-N ARQ: sender window size



a. Window size < 2^m



b. Window size = 2^m

Note:

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

Selective-Repeat ARQ

Sender and Receiver Windows

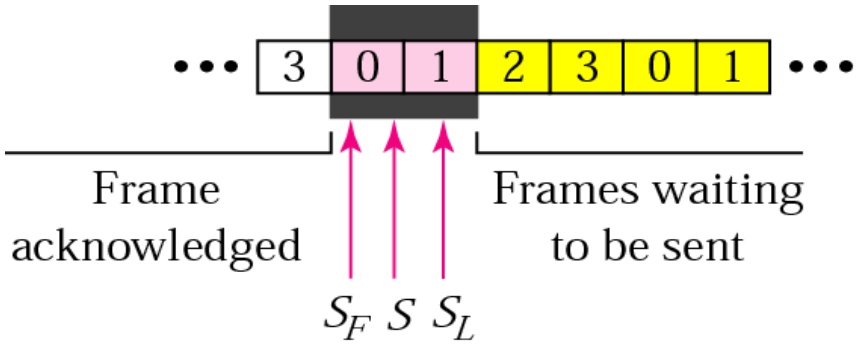
Operation

Sender Window Size

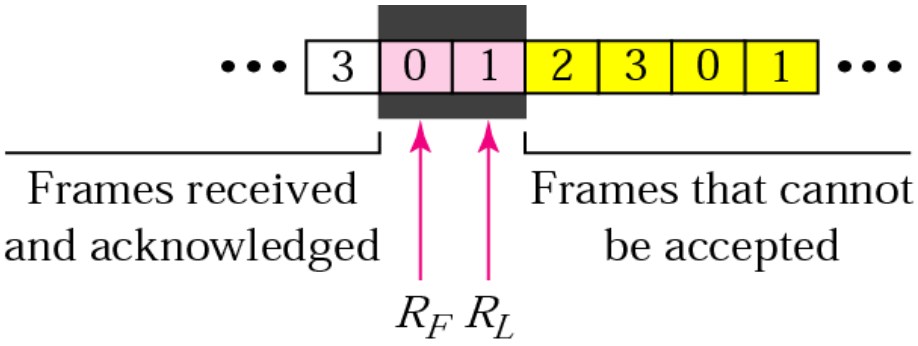
Bidirectional Transmission

Pipelining

11.12 Selective Repeat ARQ, sender and receiver windows

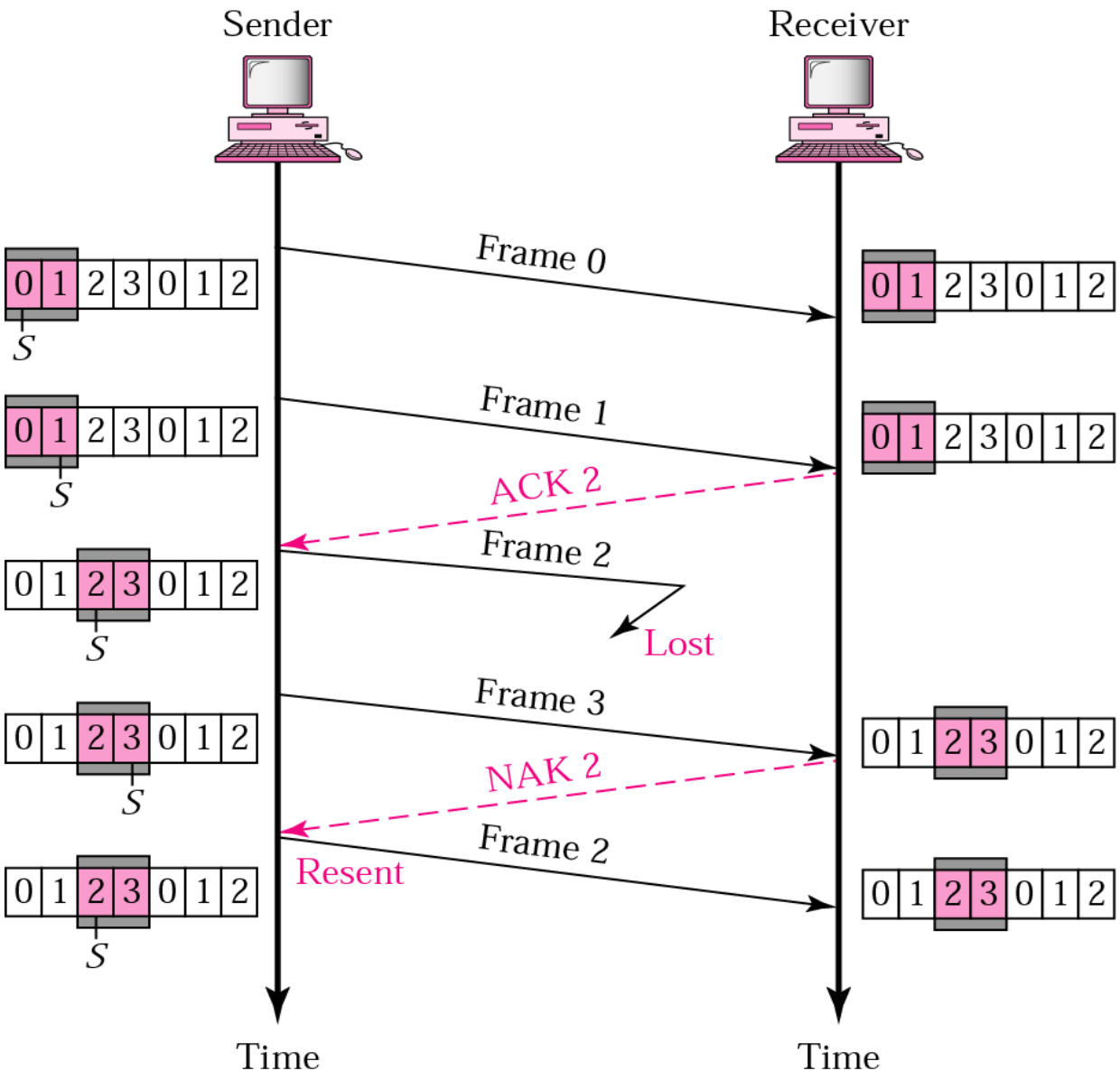


a. Sender window



b. Receiver window

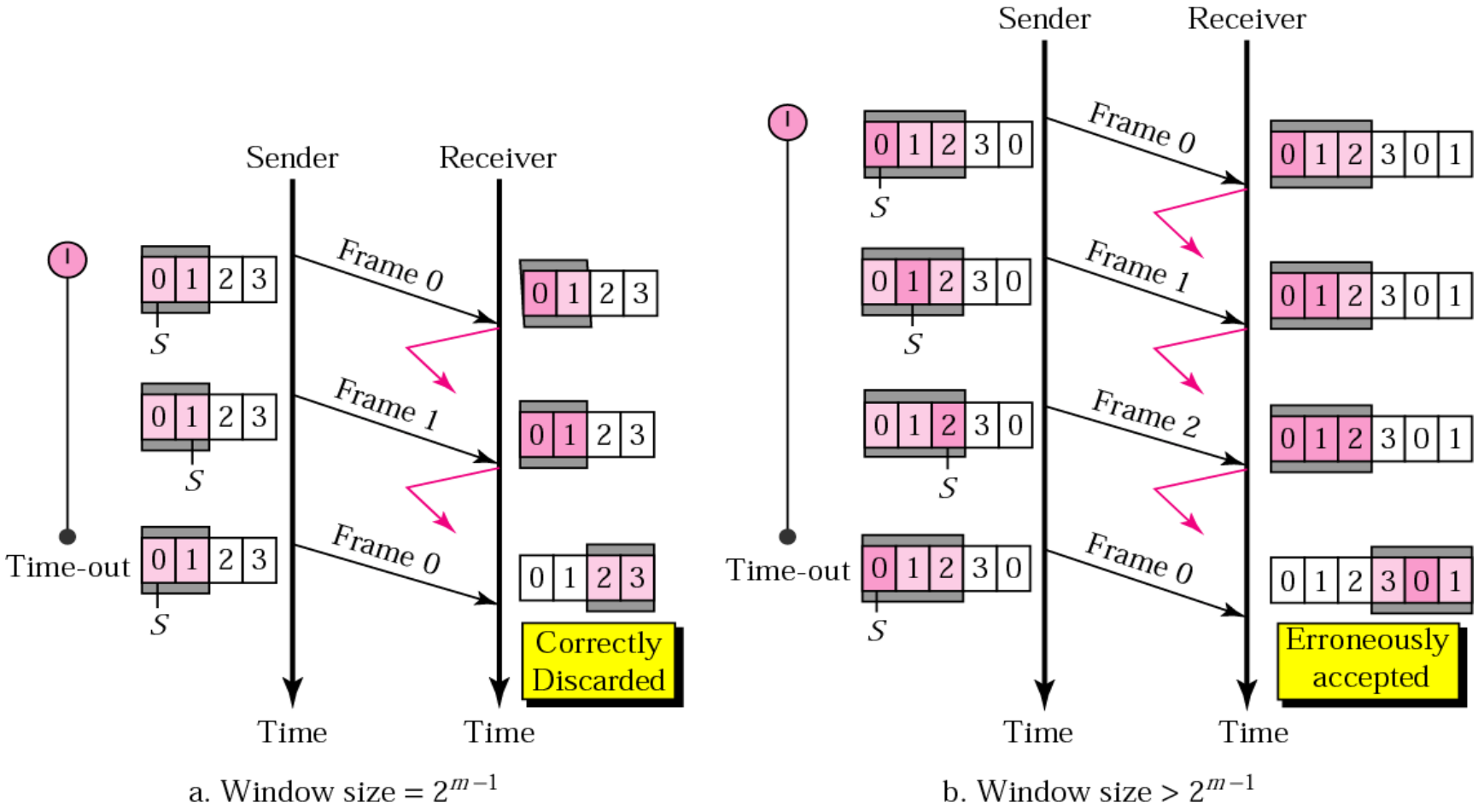
11.13 Selective Repeat ARQ, lost frame



Note:

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

11.14 Selective Repeat ARQ, sender window size



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

b. Window size > 2^{m-1}

Example 1

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

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

The system can send 20,000 bits during the time it takes for the data to go from the sender to the receiver and then back again. However, the system sends only 1000 bits. We can say that the link utilization is only 1000/20,000, or 5%. For this reason, for a link with high bandwidth or long delay, use of Stop-and-Wait ARQ wastes the capacity of the link.

Example 2

What is the utilization percentage of the link in Example 1 if the link uses Go-Back-N ARQ with a 15-frame sequence?

Solution

The bandwidth-delay product is still 20,000. The system can send up to 15 frames or 15,000 bits during a round trip. This means the utilization is 15,000/20,000, or 75 percent. Of course, if there are damaged frames, the utilization percentage is much less because frames have to be resent.

HDLC

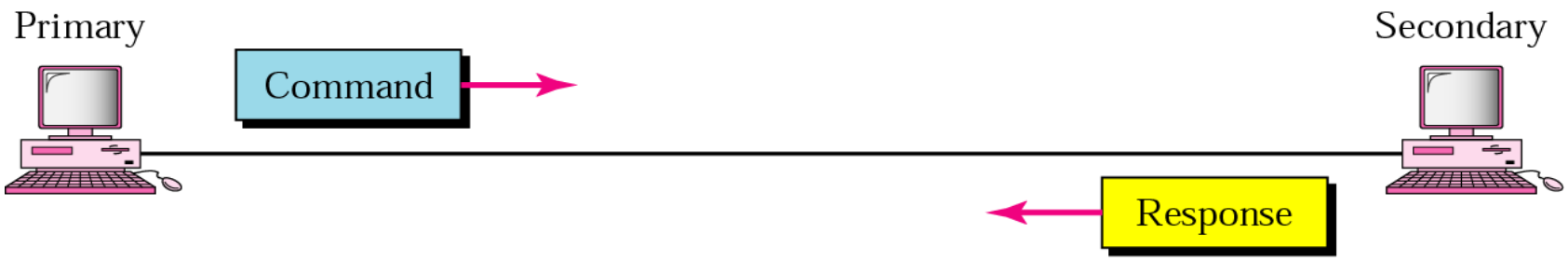
Configurations and Transfer Modes

Frames

Frame Format

Examples

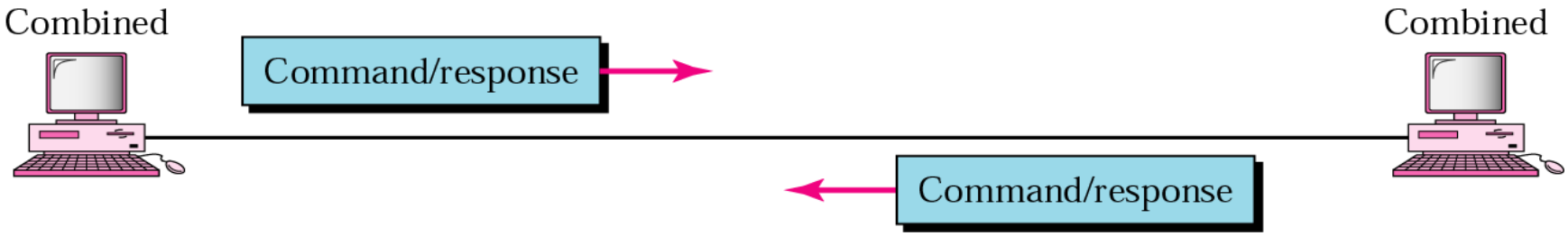
Data Transparency



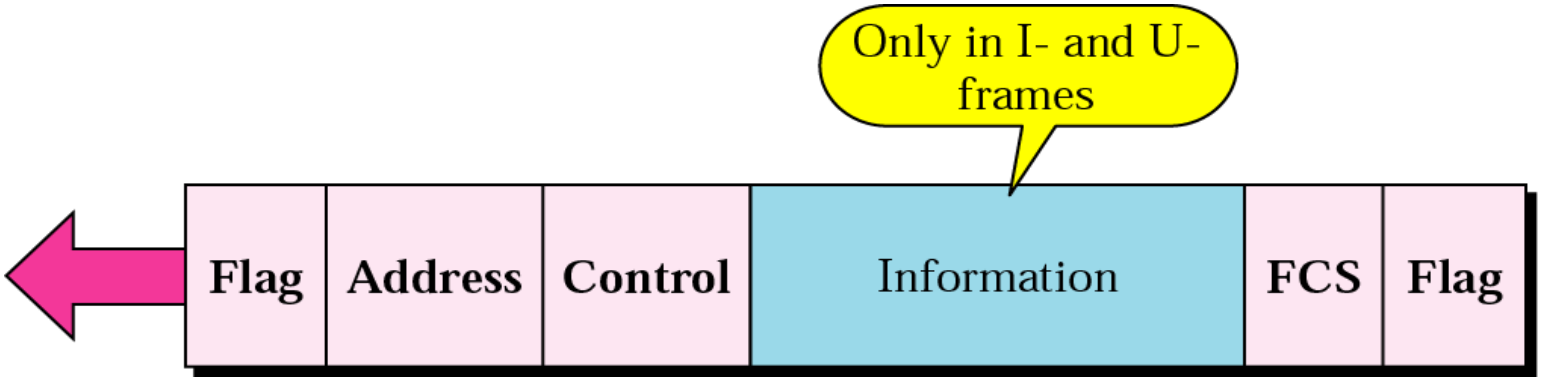
a. Point-to-point

b. Multipoint

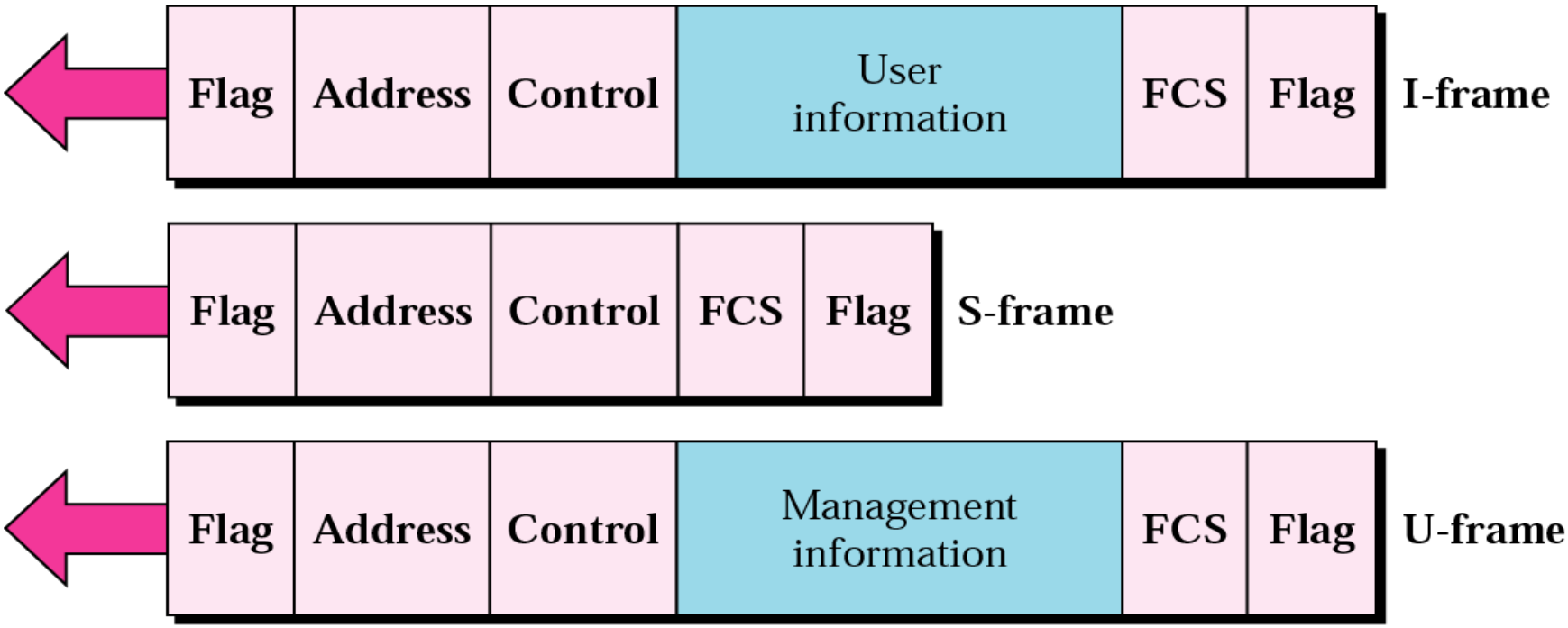
11.16 ABM



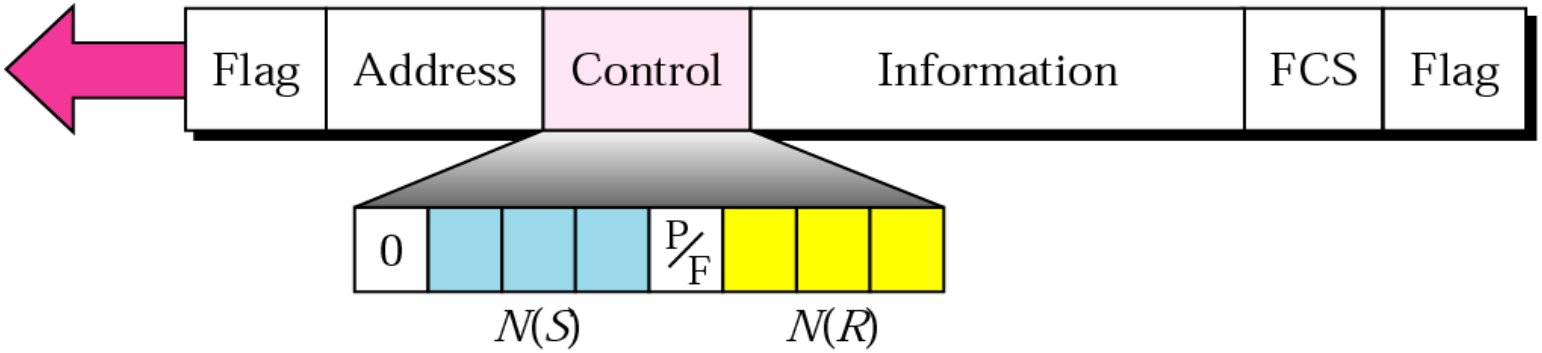
11.17 HDLC frame



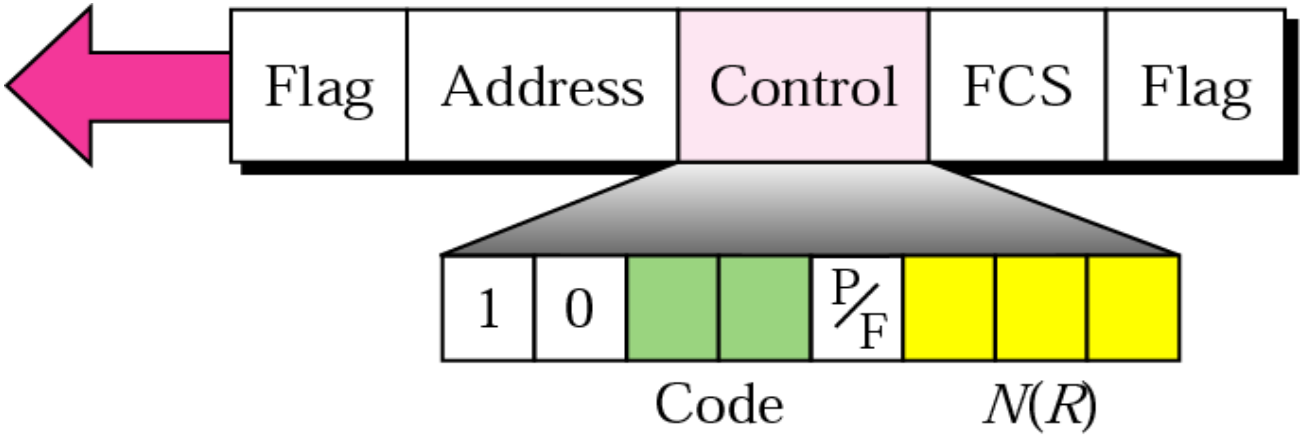
11.18 HDLC frame types



11.19 I-frame

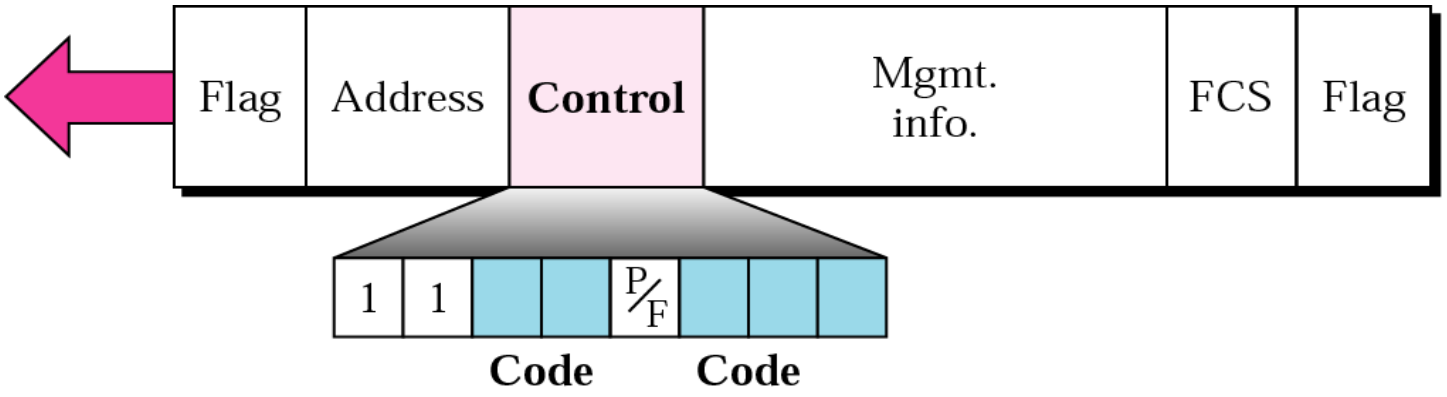


11.20 S-frame control field in HDLC



RR Receiver ready
RNR Receiver not ready
REJ Reject
SREJ Selective reject

11.21 U-frame control field in HDLC



Code		Command	Response
00	001	SNRM	
11	011	SNRME	
11	100	SABM	DM
11	110	SABME	
00	000	UI	UI
00	110		UA
00	010	DISC	RD
10	000	SIM	RIM
00	100	UP	
11	001	RSET	
11	101	XID	XID
10	001		FRMR

Table 11.1 U-frame control command and response

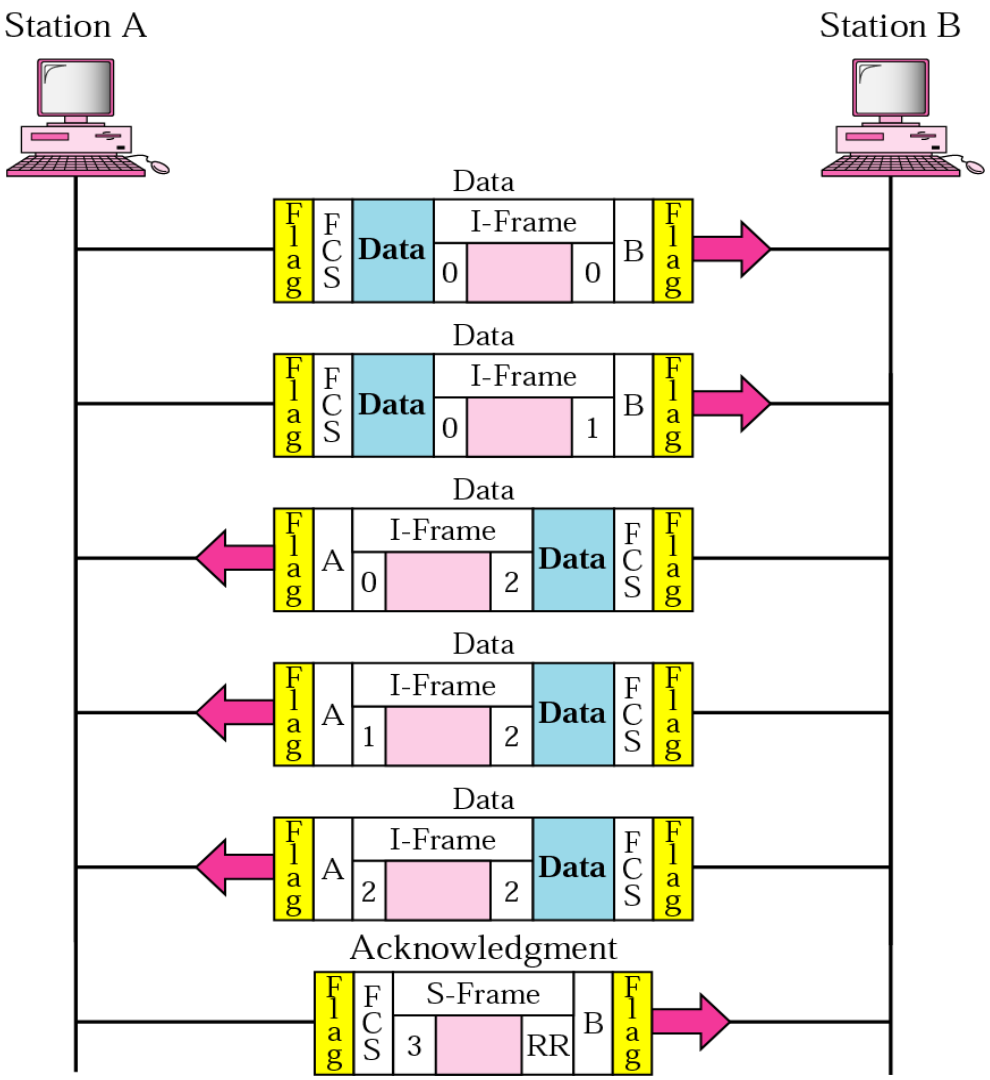
Command/response	Meaning
SNRM	Set normal response mode
SNRME	Set normal response mode (extended)
SABM	Set asynchronous balanced mode
SABME	Set asynchronous balanced mode (extended)
UP	Unnumbered poll
UI	Unnumbered information
UA	Unnumbered acknowledgment
RD	Request disconnect
DISC	Disconnect
DM	Disconnect mode
RIM	Request information mode
SIM	Set initialization mode
RSET	Reset
XID	Exchange ID
FRMR	Frame reject

Example 3

Figure 11.22 shows an exchange using piggybacking where is no error.

1. Station A begins the exchange of information with an I-frame numbered 0 followed by another I-frame numbered 1.
2. Station B piggybacks its acknowledgment of both frames onto an I-frame of its own. Station B's first I-frame is also numbered 0 [N(S) field] and contains a 2 in its N(R) field, acknowledging the receipt of A's frames 1 and 0 and indicating that it expects frame 2 to arrive next.
3. Station B transmits its second and third I-frames (numbered 1 and 2) before accepting further frames from station A. Its N(R) information, therefore, has not changed: B frames 1 and 2 indicate that station B is still expecting A frame 2 to arrive next.

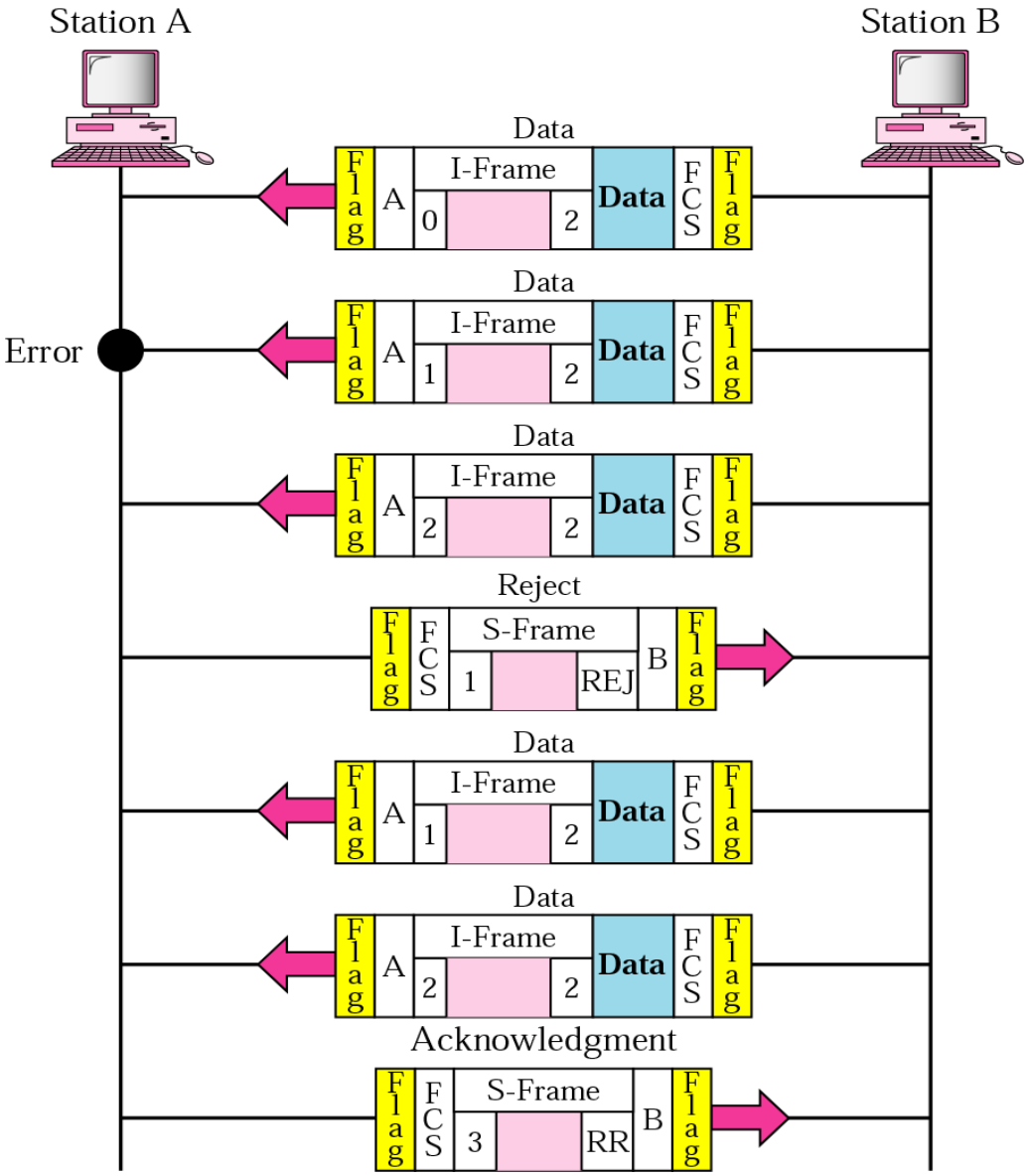
11.22 Example 3



Example 4

In Example 3, suppose frame 1 sent from station B to station A has an error. Station A informs station B to resend frames 1 and 2 (the system is using the Go-Back-N mechanism). Station A sends a reject supervisory frame to announce the error in frame 1. Figure 11.23 shows the exchange.

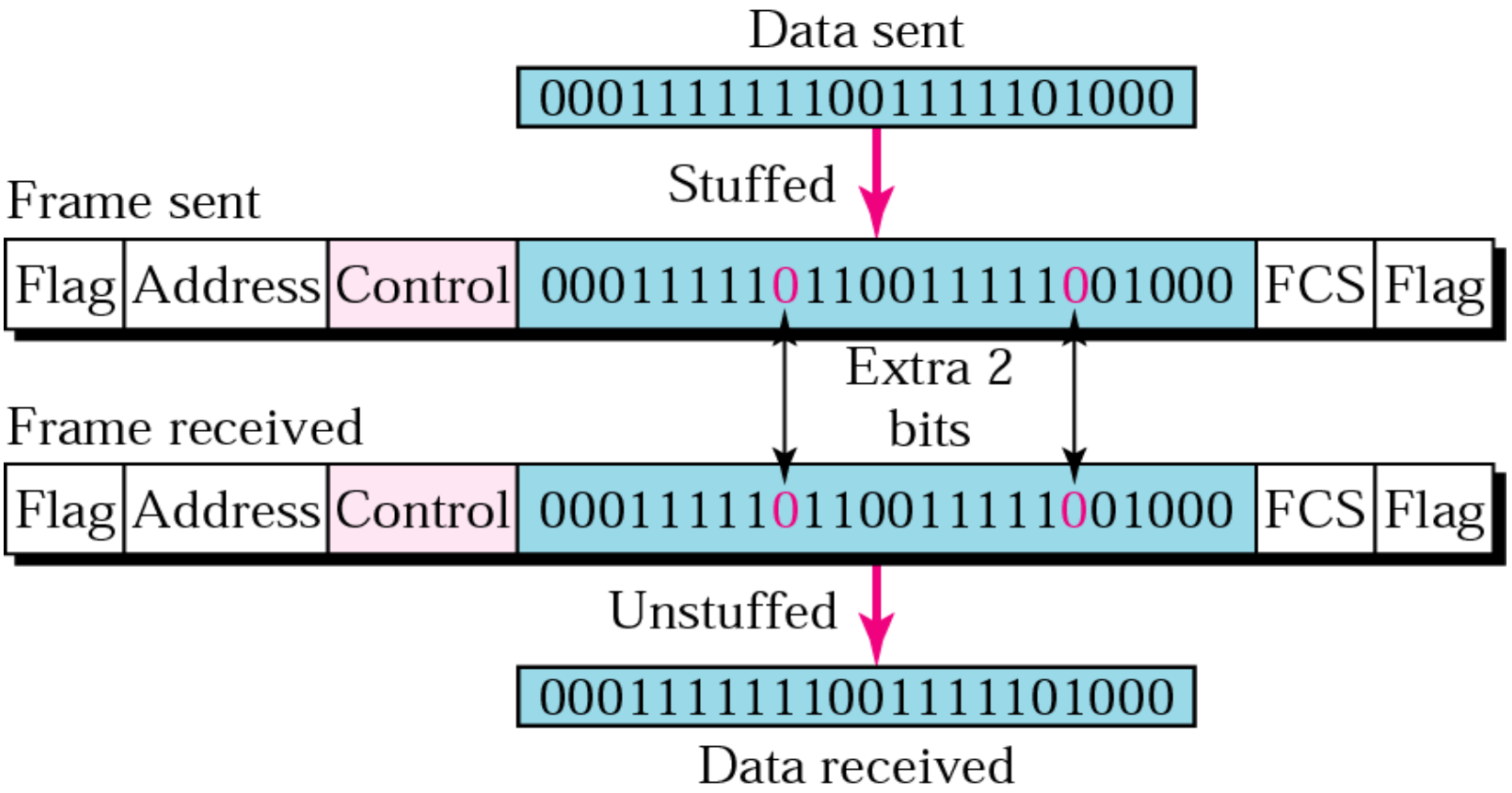
11.23 Example 4



Note:

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

11.24 Bit stuffing and removal



11.25 Bit stuffing in HDLC