

Chapter 7

Data Link Control

Figure 7-1

Categories of Flow Control

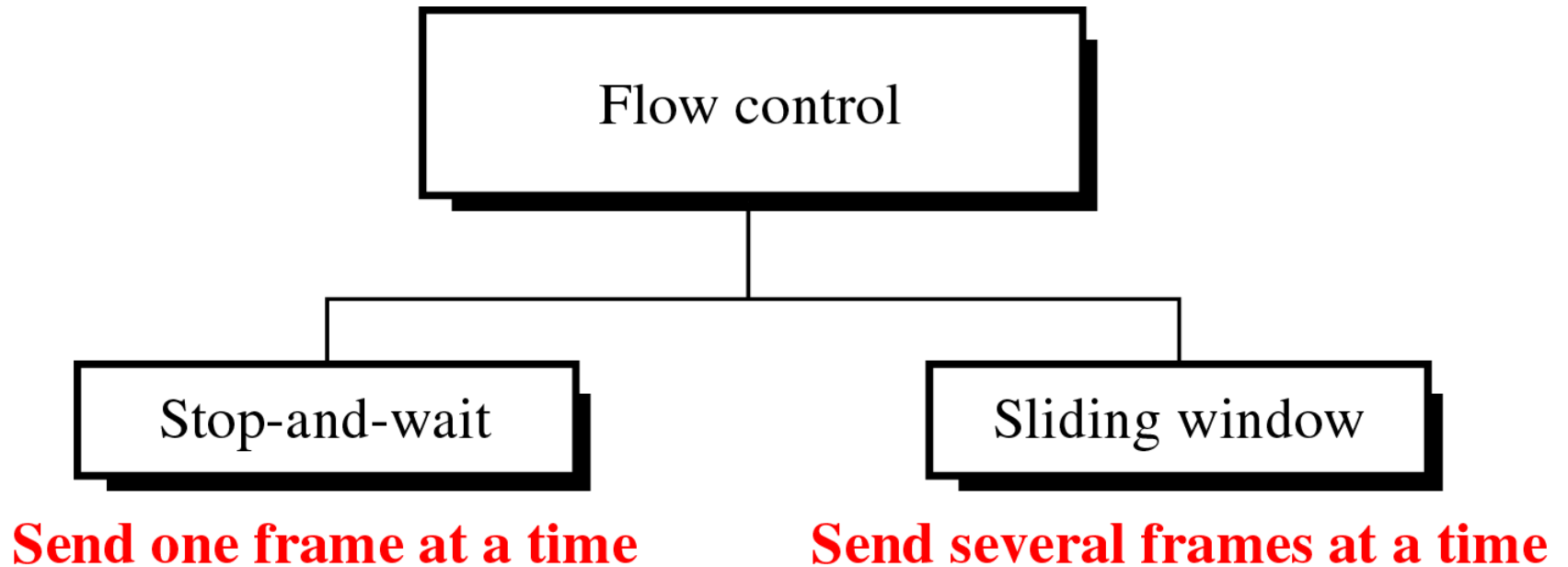
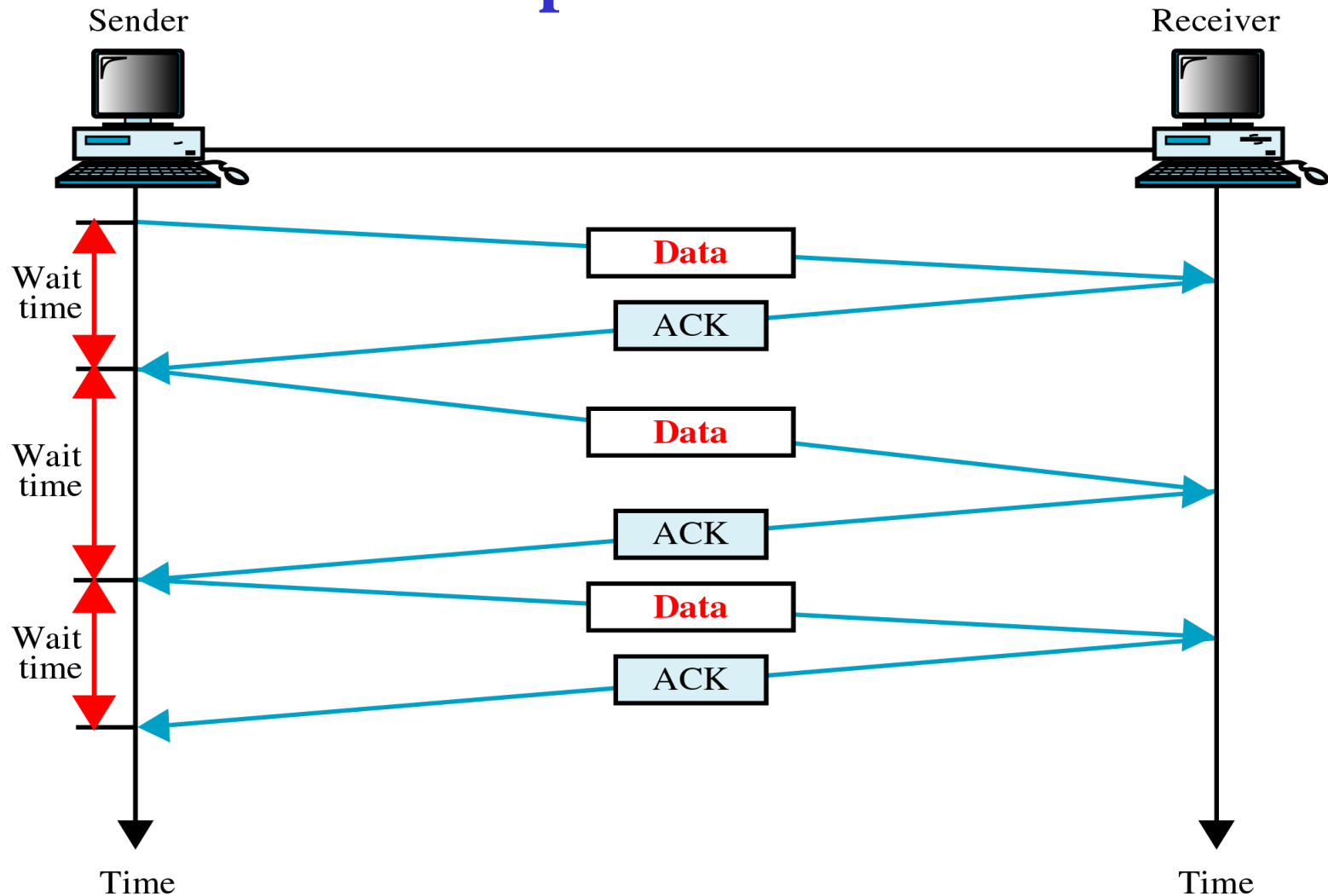


Figure 7-2

Stop-and-Wait



Adv: simplicity

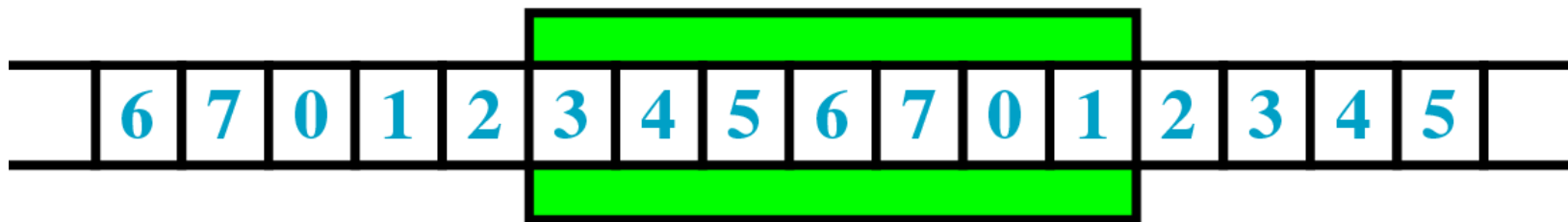
Disadv: inefficient

Figure 7-3

Sliding Window

- The sender can send transmit several frames before needing an acknowledgement
- The receiver acknowledges only some of the frames, using a single ACK to confirm the receipt of multiple data frames

Window



- Sliding window: refers to imaginary boxes at both the sender and receiver.
- Frames may be ACK'ed at any point without waiting for the window to fill up and may be transmitted as long as the window is not yet full
- Frames are numbered modulo N: 0, 1, 2, ..., N-1
- Window size cannot exceed N-1 \rightarrow max. number of N-1 frames can be sent before an ACK is required
- An ACK with number K means all frames up thru K-1 have been received.

Figure 7-4

Sender Sliding Window

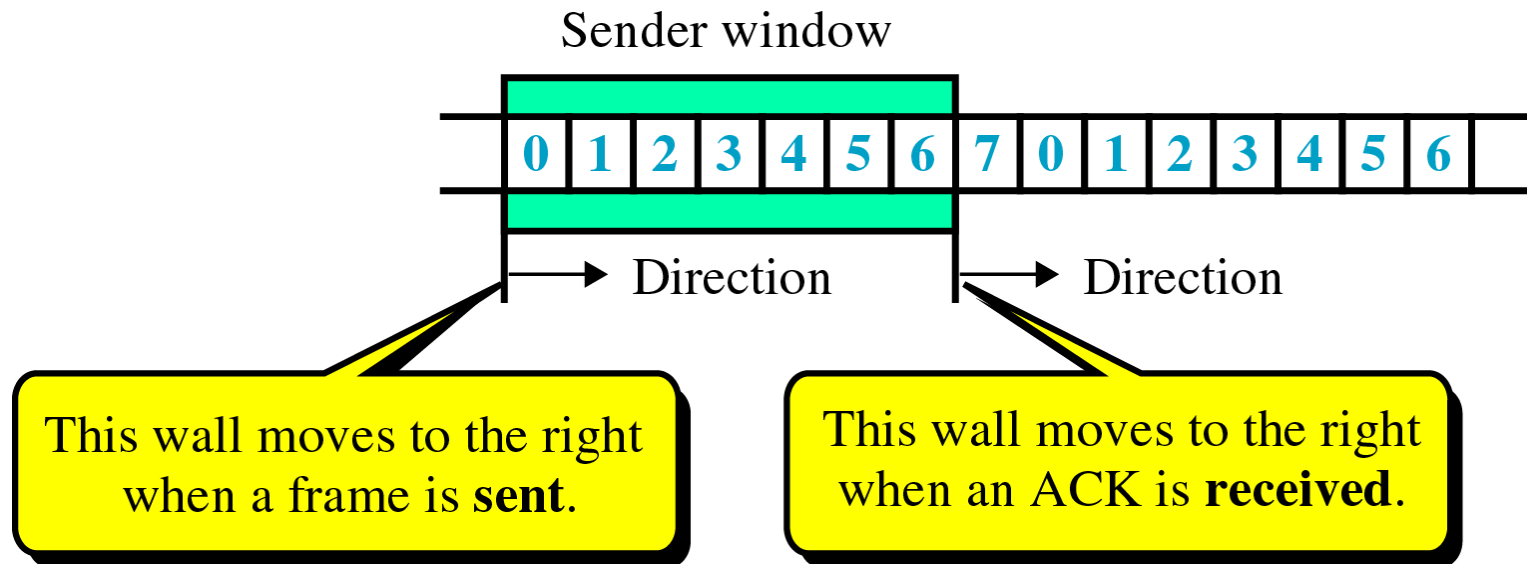


Figure 7-5

Receiver Sliding Window

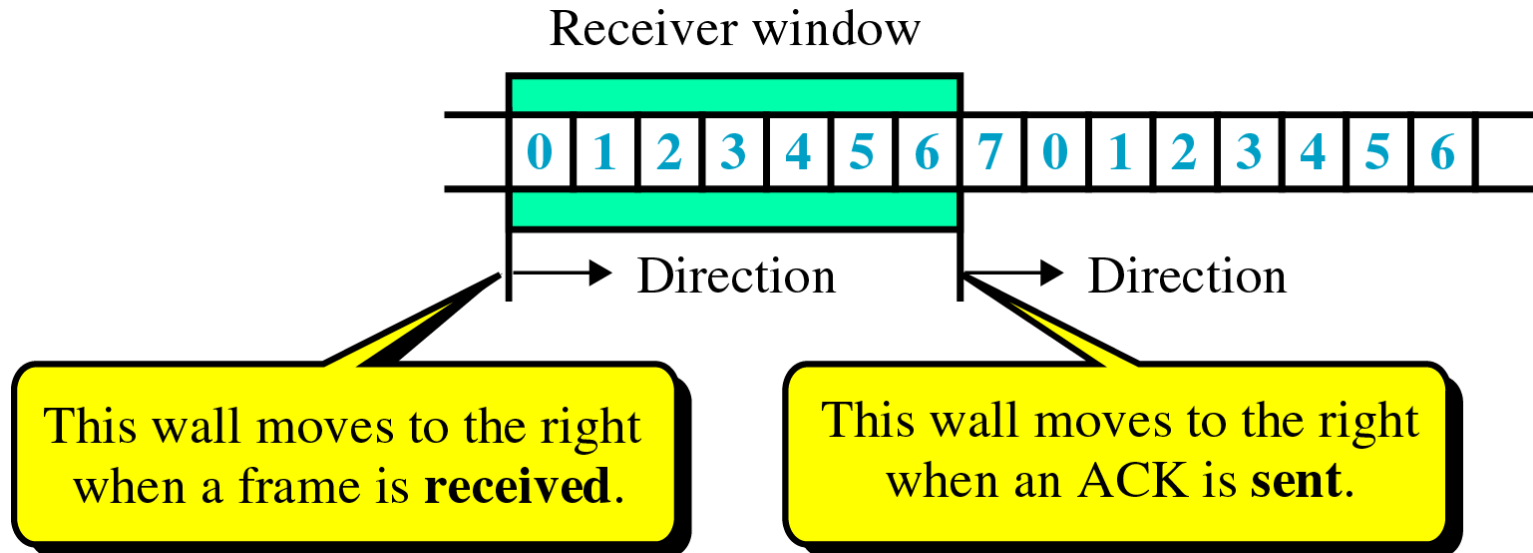


Figure 7-6

Example of Sliding Window

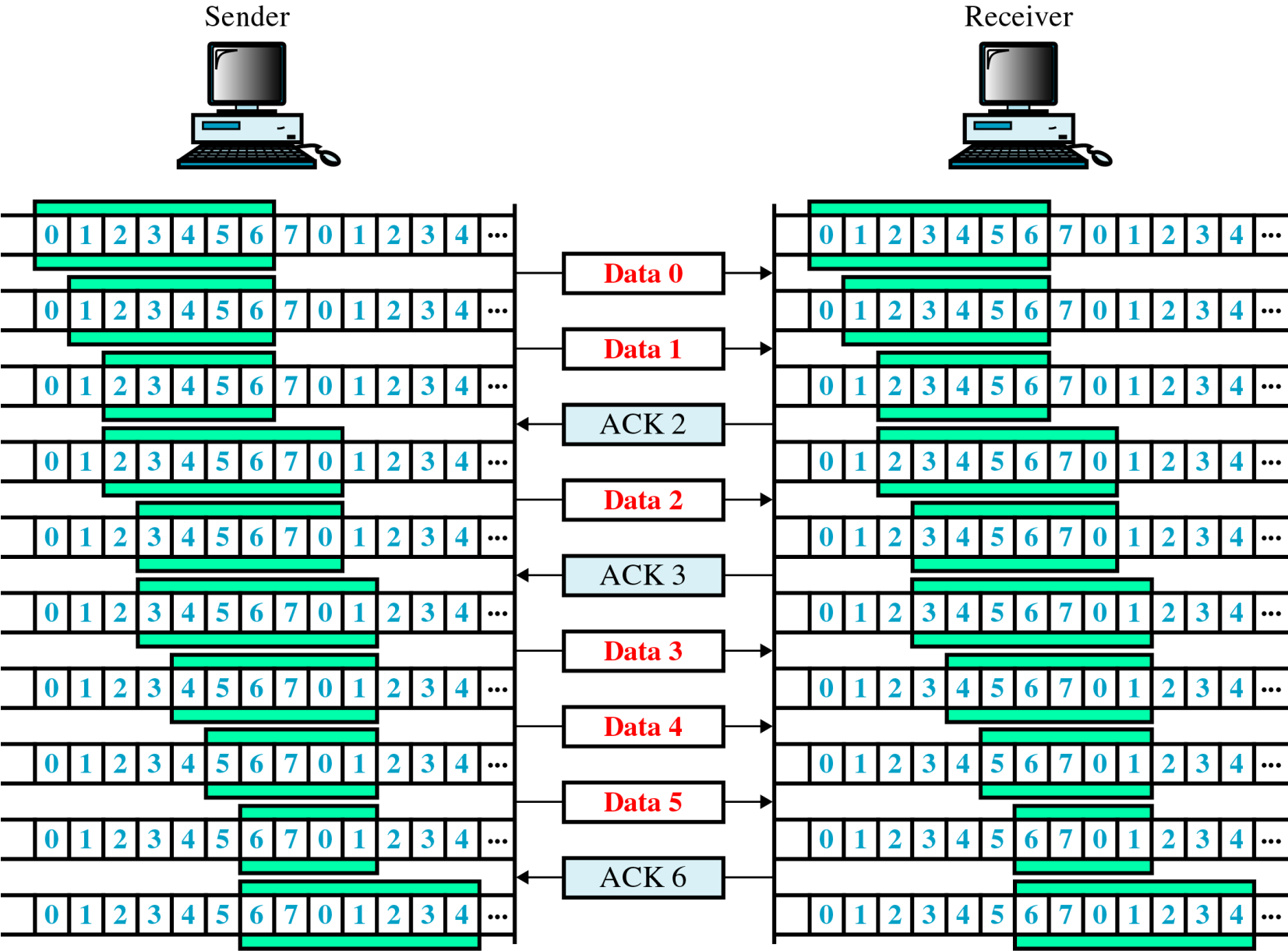
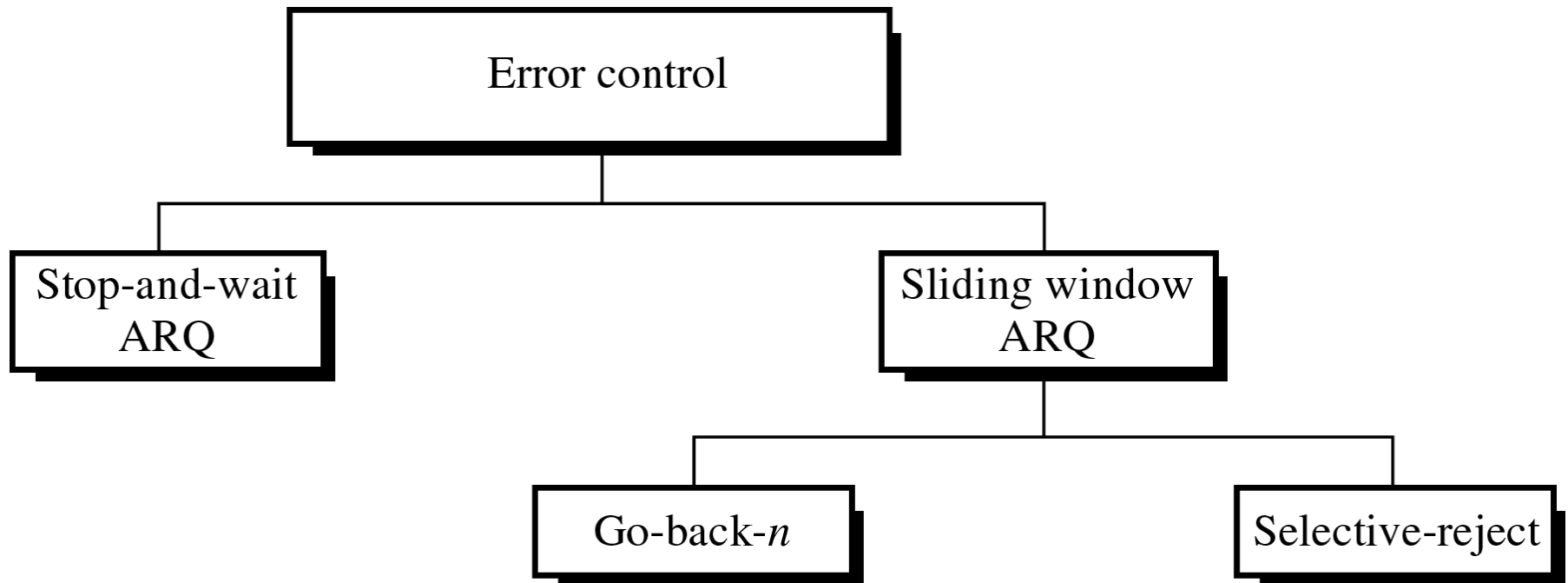


Figure 7-7

Categories of Error Control



Stop-and-Wait ARQ

- A form of stop-and-wait flow control extended to include retransmission of data in case of lost or damaged frames
- Four features are added to the basic flow control mechanism:
 1. Sender keeps a copy of the last frame transmitted until it receives an **ACK** for that frame
 2. Both data frames and ACK frames are numbered 0 and 1 alternately
 3. A **NAK** frame, which is not numbered, is returned if an error is discovered.
 4. Sender is equipped with a **timer**.

Figure 7-8

Stop-and-Wait ARQ, Damaged Frame

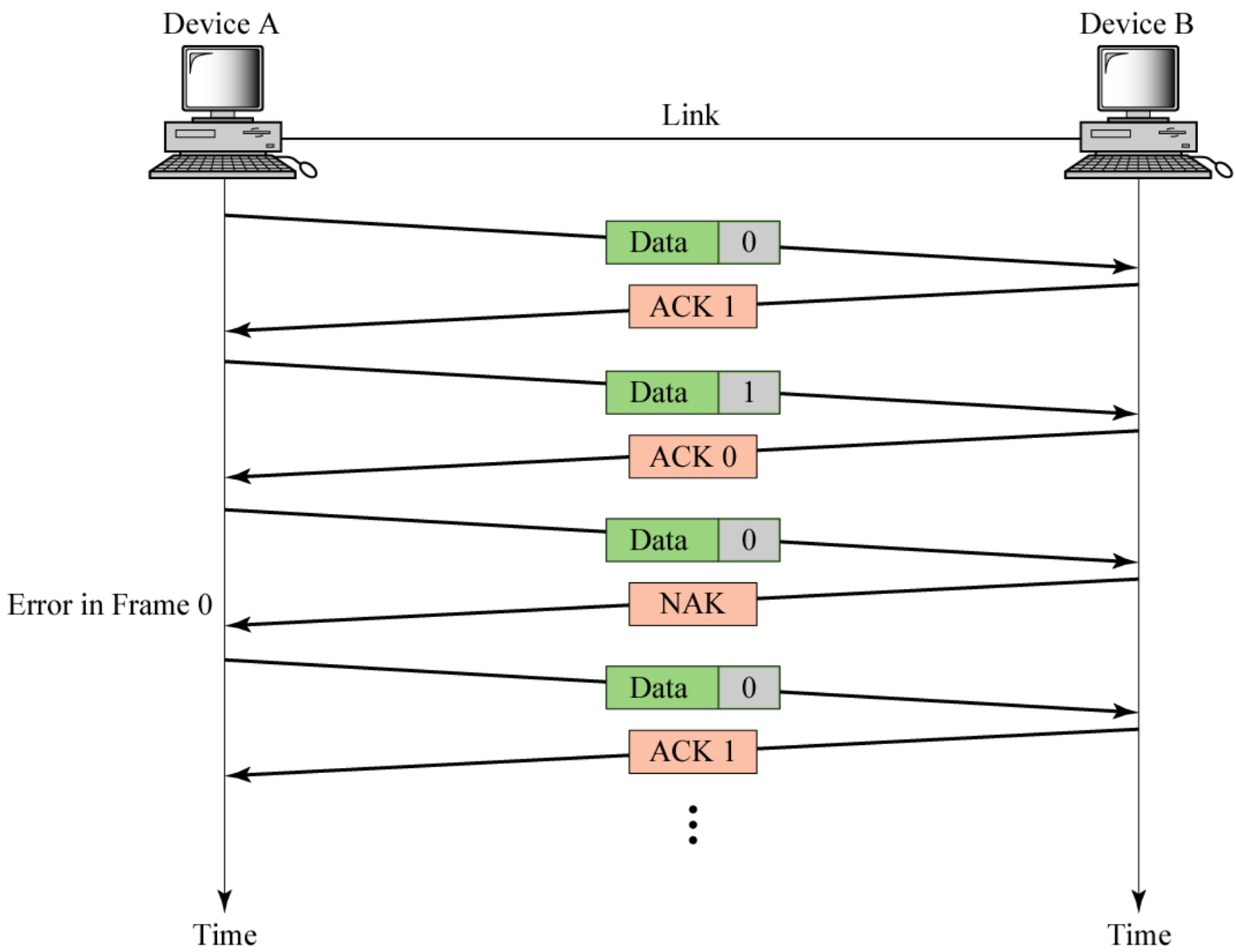


Figure 7-9

Stop-and-Wait ARQ, Lost Frame

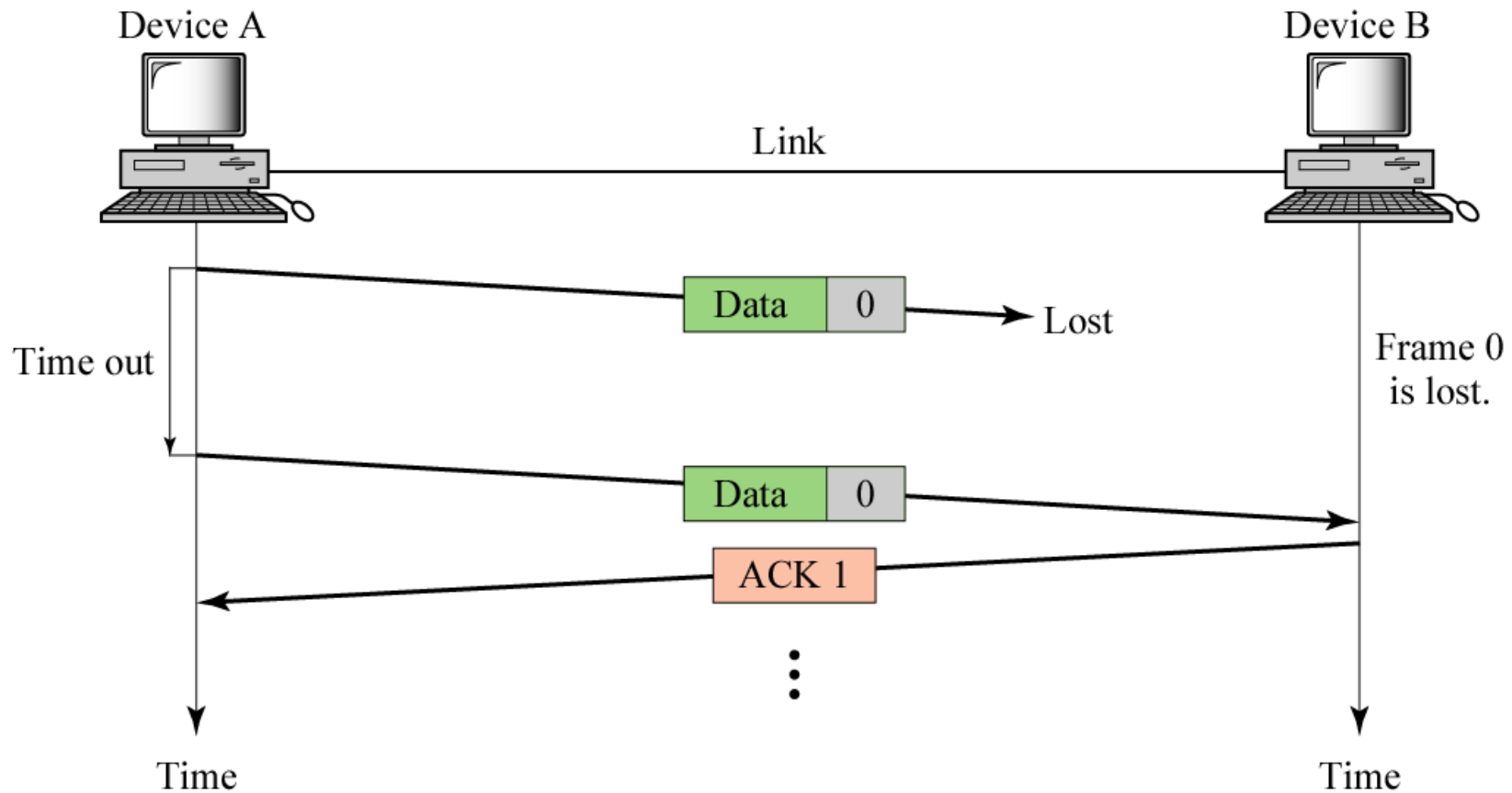
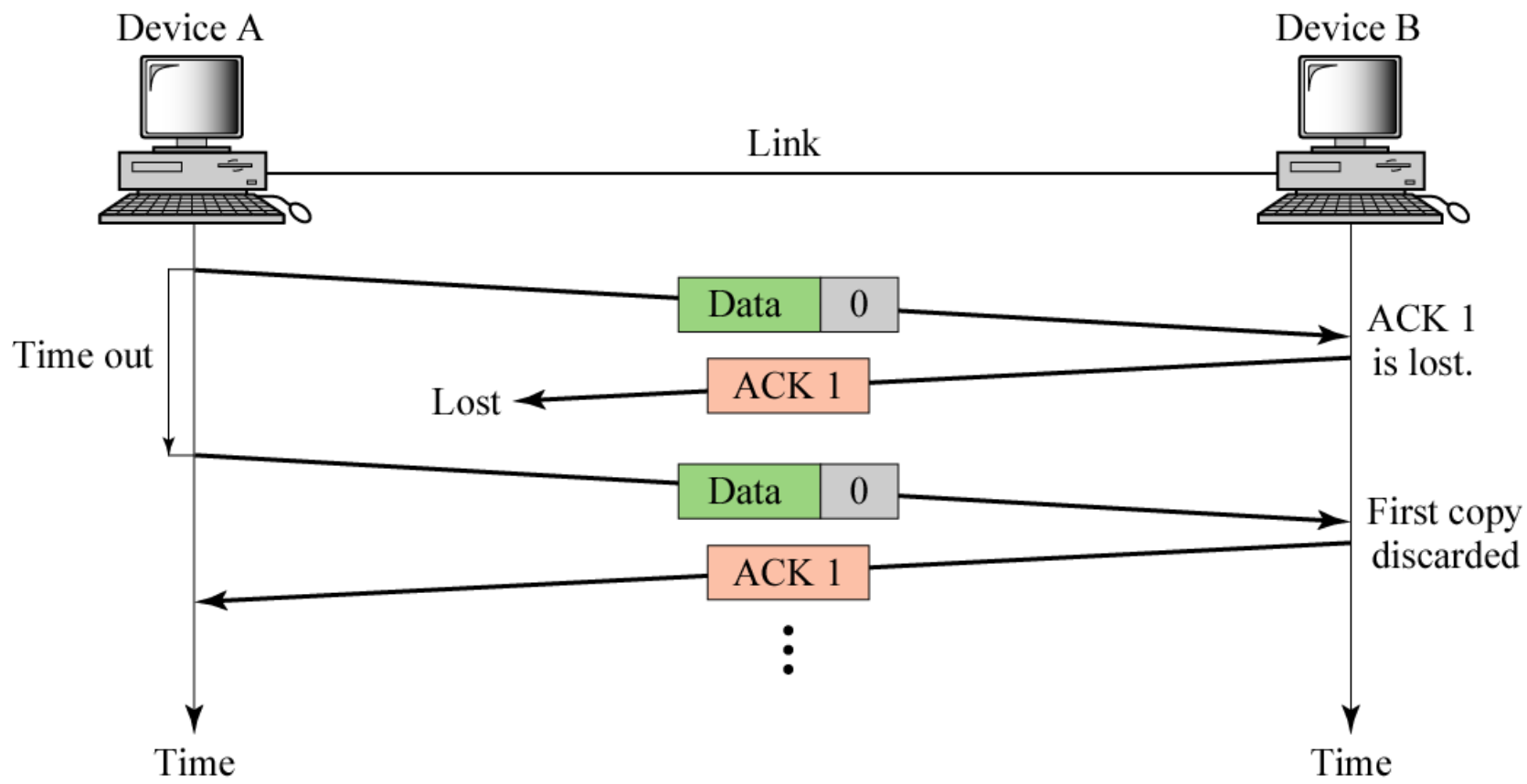


Figure 7-10

Stop-and-Wait ARQ, Lost ACK



Sliding Window ARQ

- A form of sliding window flow control
Two variants: **go-back-n ARQ** and **selective-reject ARQ**
- Three features are added to the basic flow control mechanism:
 1. Sender keeps copies of all transmitted frames until they have been acknowledged.
 2. In addition to ACK frames, the receiver has the option of returning a NAK frame if the data have been received damaged.
Both ACK and NAK frames are numbered.
 3. Sender is equipped with a timer. The sender starts the timer and waits before sending any more if **n-1** frames are awaiting acknowledgment.
- In go-back-n ARQ, if one frame is lost or damaged, **all frames sent since the last frame acknowledged** are retransmitted.

Figure 7-11

Go-Back-n, Damaged Frame

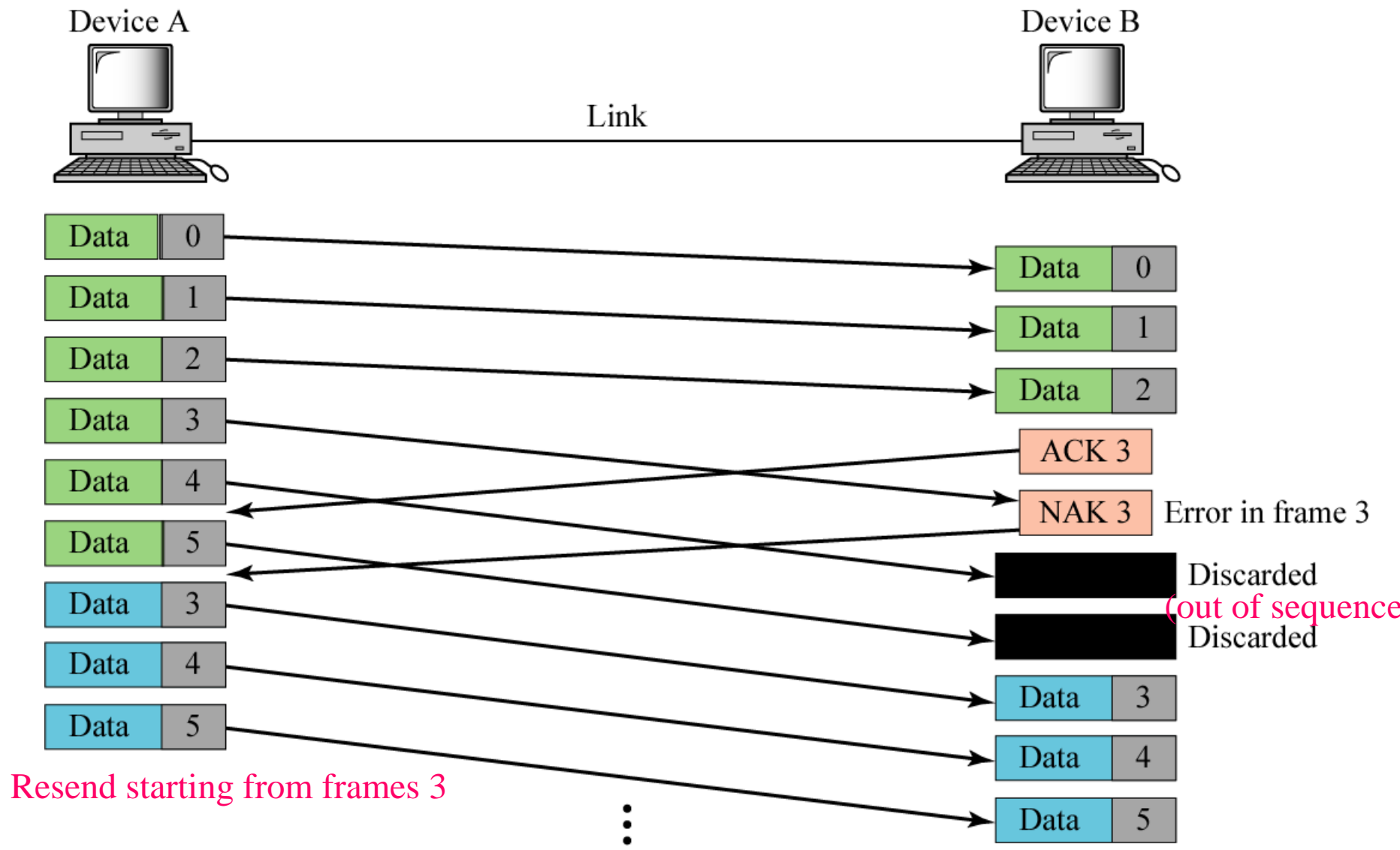
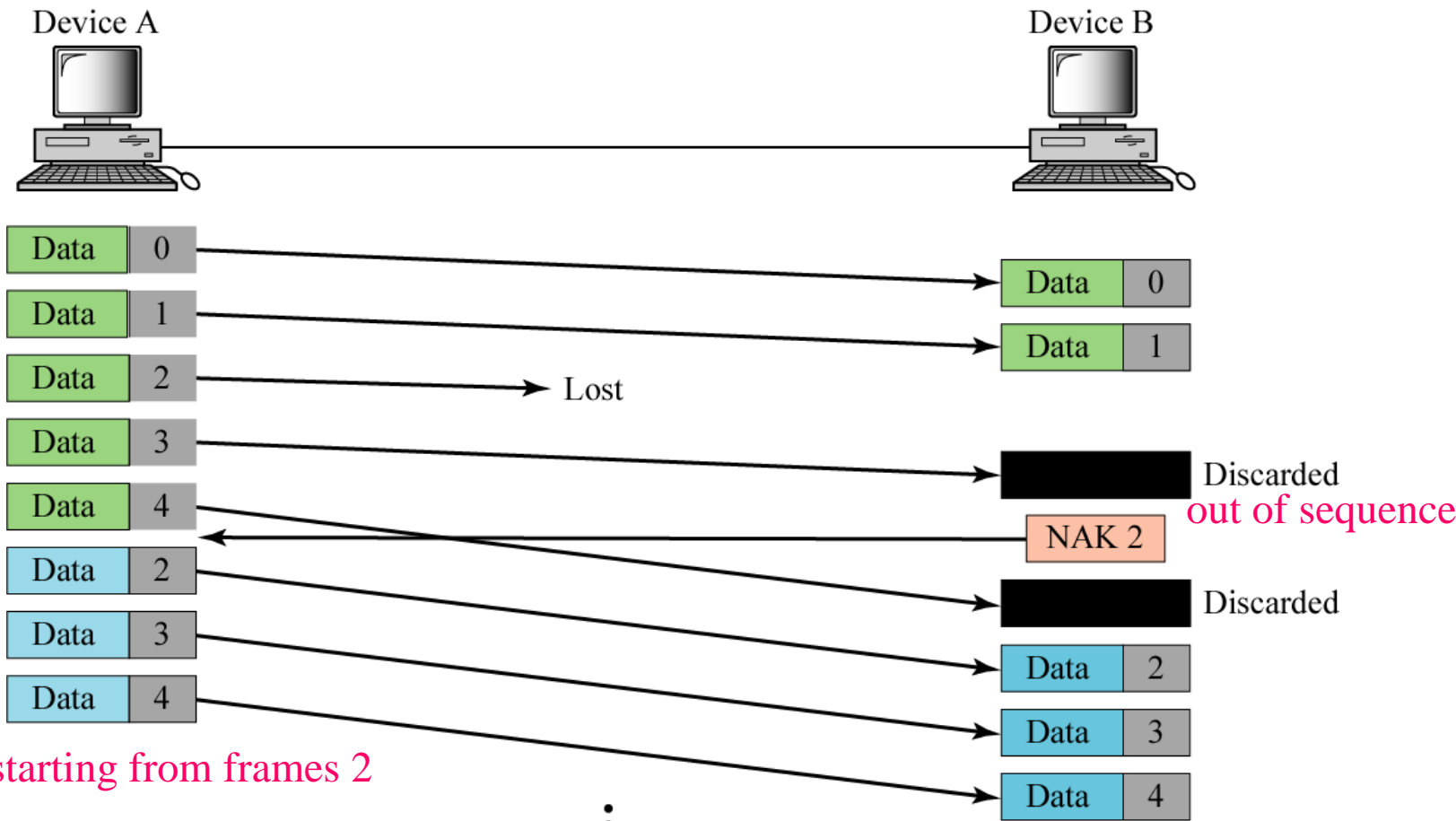


Figure 7-12

Go-Back-n, Lost Frame



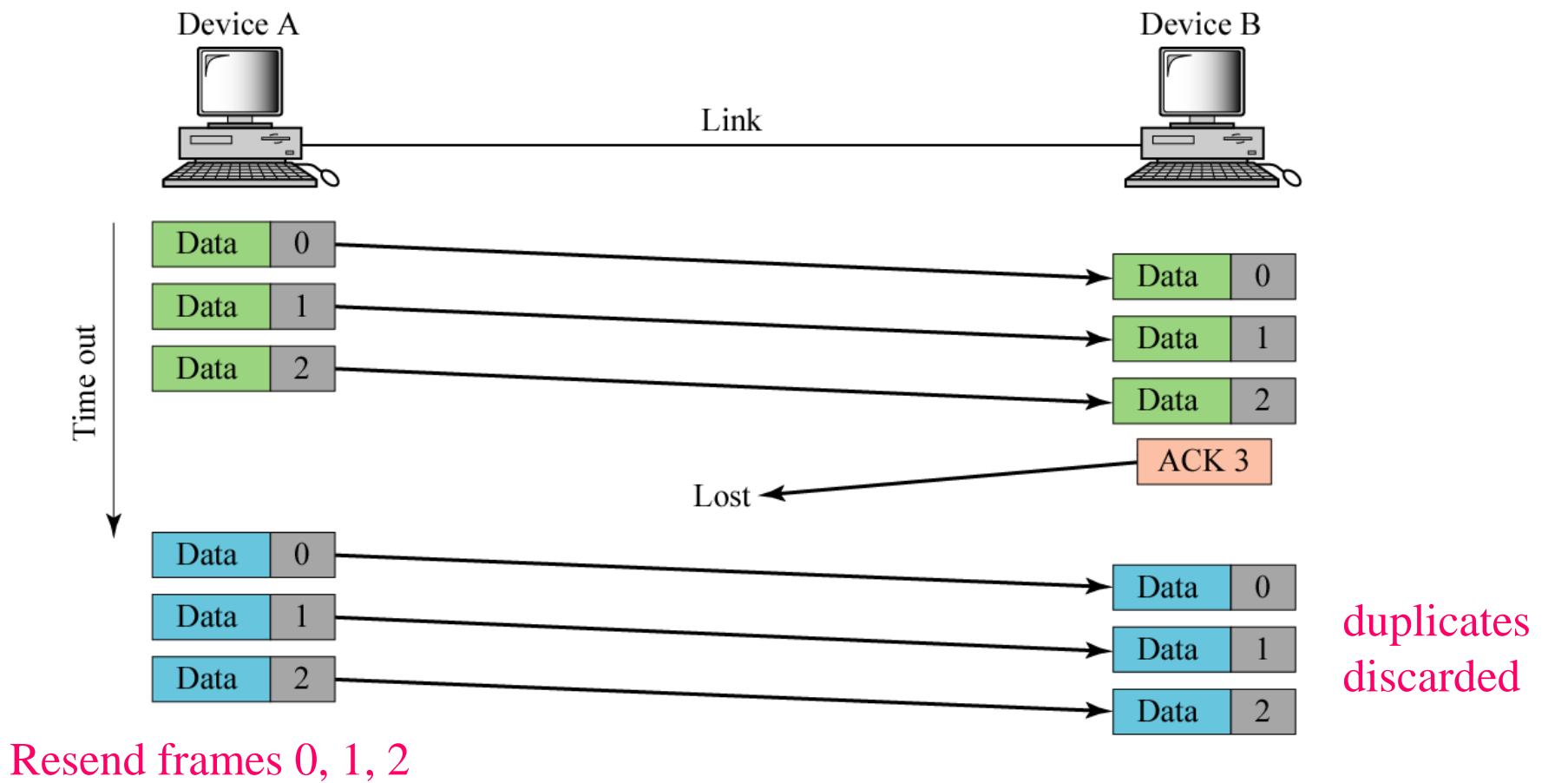
Resend starting from frames 2

NAK 2 means two things: 1. Something is wrong with Frame 2
2. All Frames up thru number 1 received

Figure 7-13

Go-Back-n, Lost ACK

(n = 4, window size = 3)

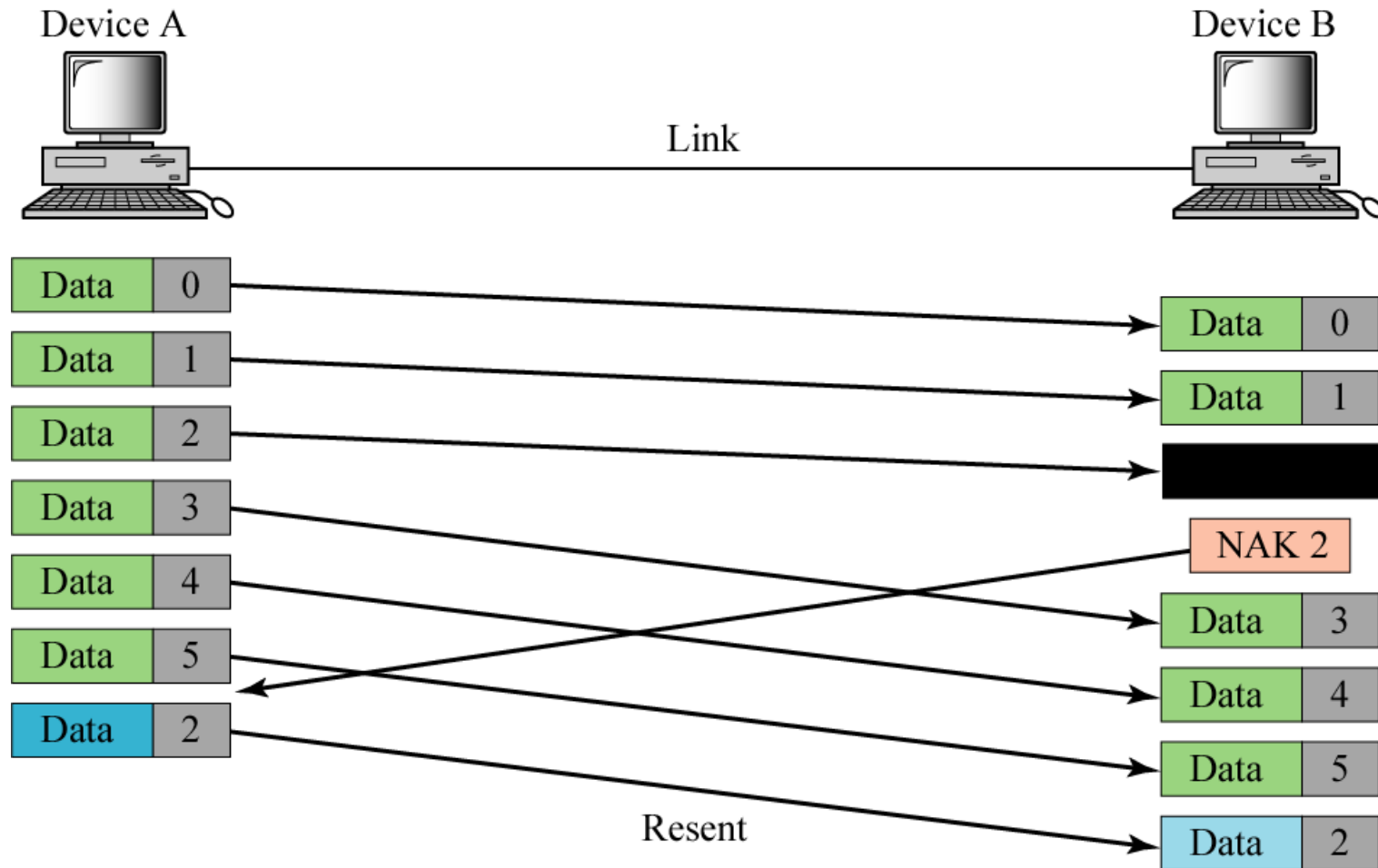


Selective-Reject ARQ

- Only the specific damaged or lost frame is retransmitted.
- Differences between go-back-n and selective-reject ARQ:
 1. Receiver must contain sorting logic to reorder frames received out-of-sequence
 2. Sender must contain a searching mechanism to find and select only the requested frame for retransmission.
 3. Receiver must keep all previously received frames on hold until all retransmissions have been sorted and any duplicates have been identified and discarded.
 4. ACK numbers, like NAK numbers, refers to the frame received (or lost) instead of the next frame expected.
 5. Max. window size = $(n+1)/2$.
(Note: $n-1$ is the go-back-n window size)

Figure 7-14

Selective-Reject, Damaged Frame



Resend only frame 2