TCP
Congestion Control

- What is **congestion**?
  - A state occurring in network layer when the message traffic is so heavy that it slows down network response time.
- **Effects** of Congestion
  - As delay increases, performance decreases.
  - If delay increases, retransmission occurs, making situation worse.

Window size

- Generally the sender window size is determined by the available buffer space in the receiver (rwnd).
- If the network cannot deliver the data as fast as they are created by the sender, it must tell the sender to slow down.
- In other words, in addition to the receiver, the network is a second entity that determines the size of the sender's window.

Actual window size = minimum (rwnd, cwnd)

rwnd- receiver window; cwnd- congestion window

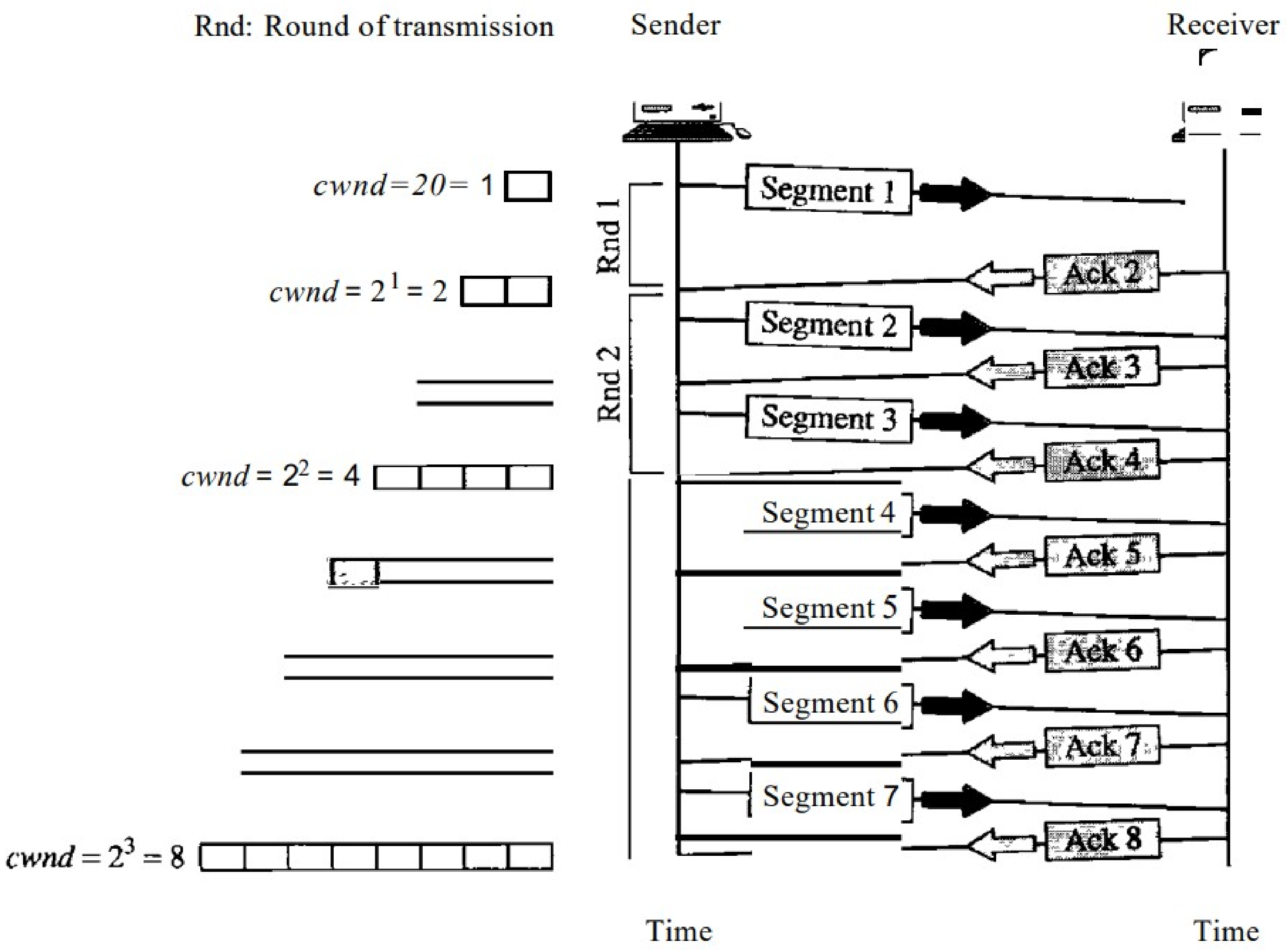
Congestion policy

- TCP's general policy for handling congestion is based on three phases:
- Slow start,
- Congestion avoidance,
- Congestion detection.

Slow start

- Slow Start: Exponential Increase
- One of the algorithms used in TCP congestion control is called slow start.
- This algorithm is based on the idea that the size of the congestion window (cwnd) starts with one maximum segment size (MSS).

Figure 24.8 *Slow start, exponential increase*



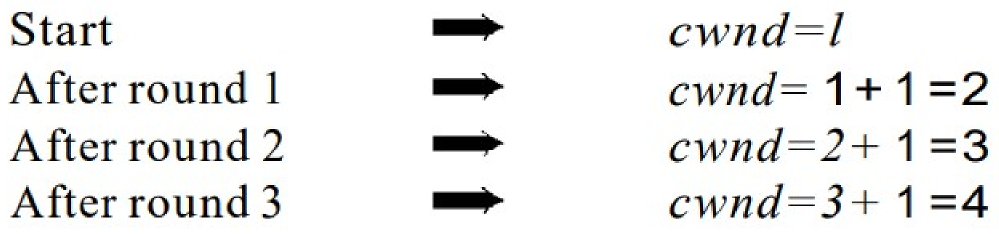
- In the slow-start algorithm, the size of the congestion window increases exponentially until it reaches a threshold.

Start	➡	$cwnd=1$
After round 1	➡	$cwnd=2^1=2$
After round 2	➡	$cwnd=2^2=4$
After round 3	➡	$cwnd=2^3=8$

Congestion avoidance

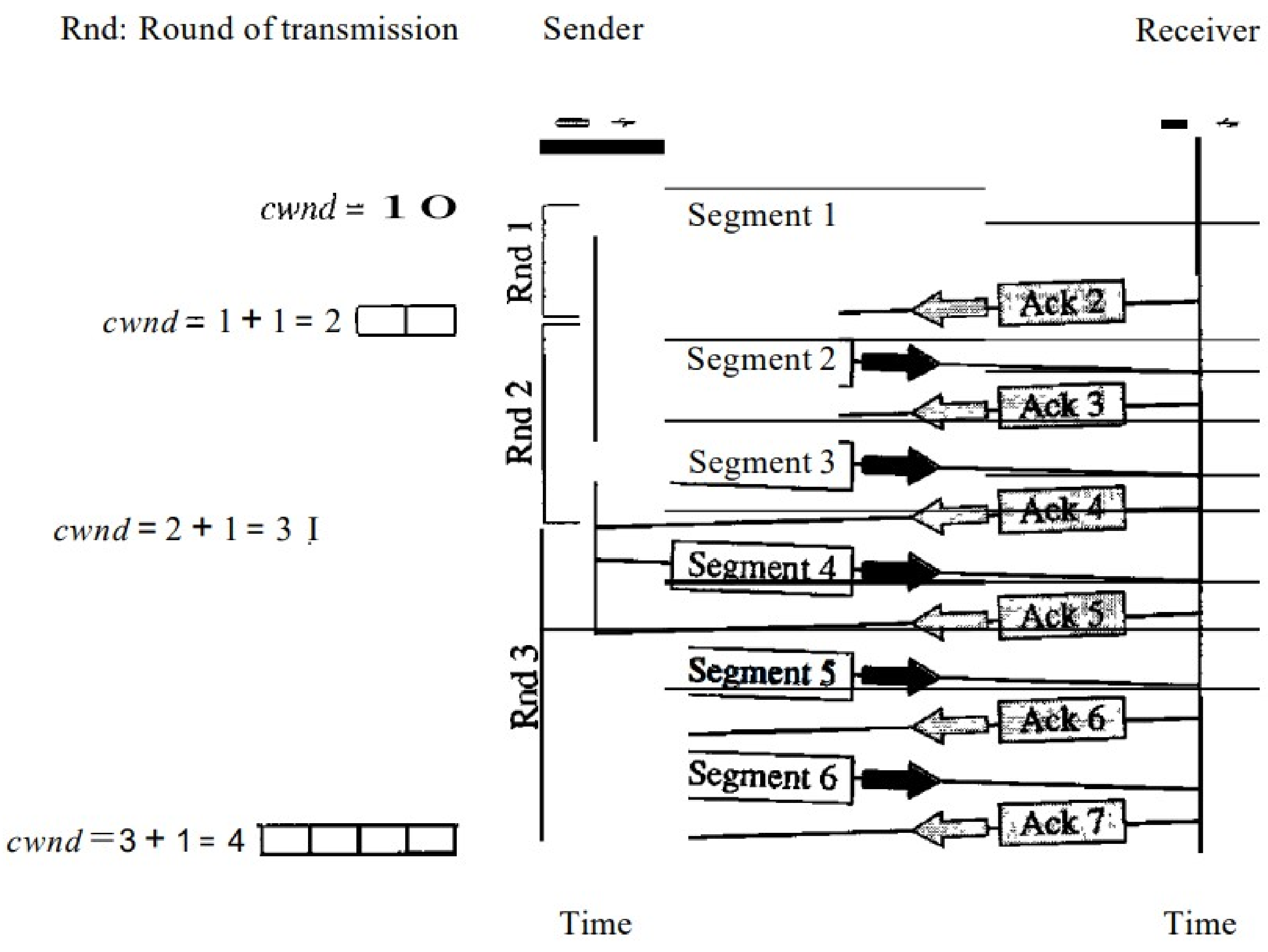
- Congestion avoidance- which undergoes an additive increase instead of an exponential one.
- When the size of the congestion window reaches the slow-start threshold, the slow-start phase stops and the additive phase begins.

In the congestion avoidance algorithm, the size of the congestion window increases additively until congestion is



Start	➡	*cwnd*=*l*
After round 1	➡	*cwnd*= 1+ 1 =2
After round 2	➡	*cwnd*=*2*+ 1 =3
After round 3	➡	*cwnd*=*3*+ 1 =4

Figure 24.9 *Congestion avoidance, additive increase*



Congestion Detection

- Congestion Detection: Multiplicative Decrease
- If congestion occurs, the congestion window size must be decreased.
- The only way the sender can guess that congestion has occurred is by the need to retransmit a segment.
- However, retransmission can occur in one of two cases: when a timer times out or when three ACKs are received.

- I. If a time-out occurs, there is a stronger possibility of congestion; a segment has probably been dropped in the network, and there is no news about the sent segments.

In this case TCP reacts strongly:

a. It sets the value of the threshold to one-half of the current window size.

b. It sets *cwnd* to the size of one segment.

c. It starts the slow-start phase again.

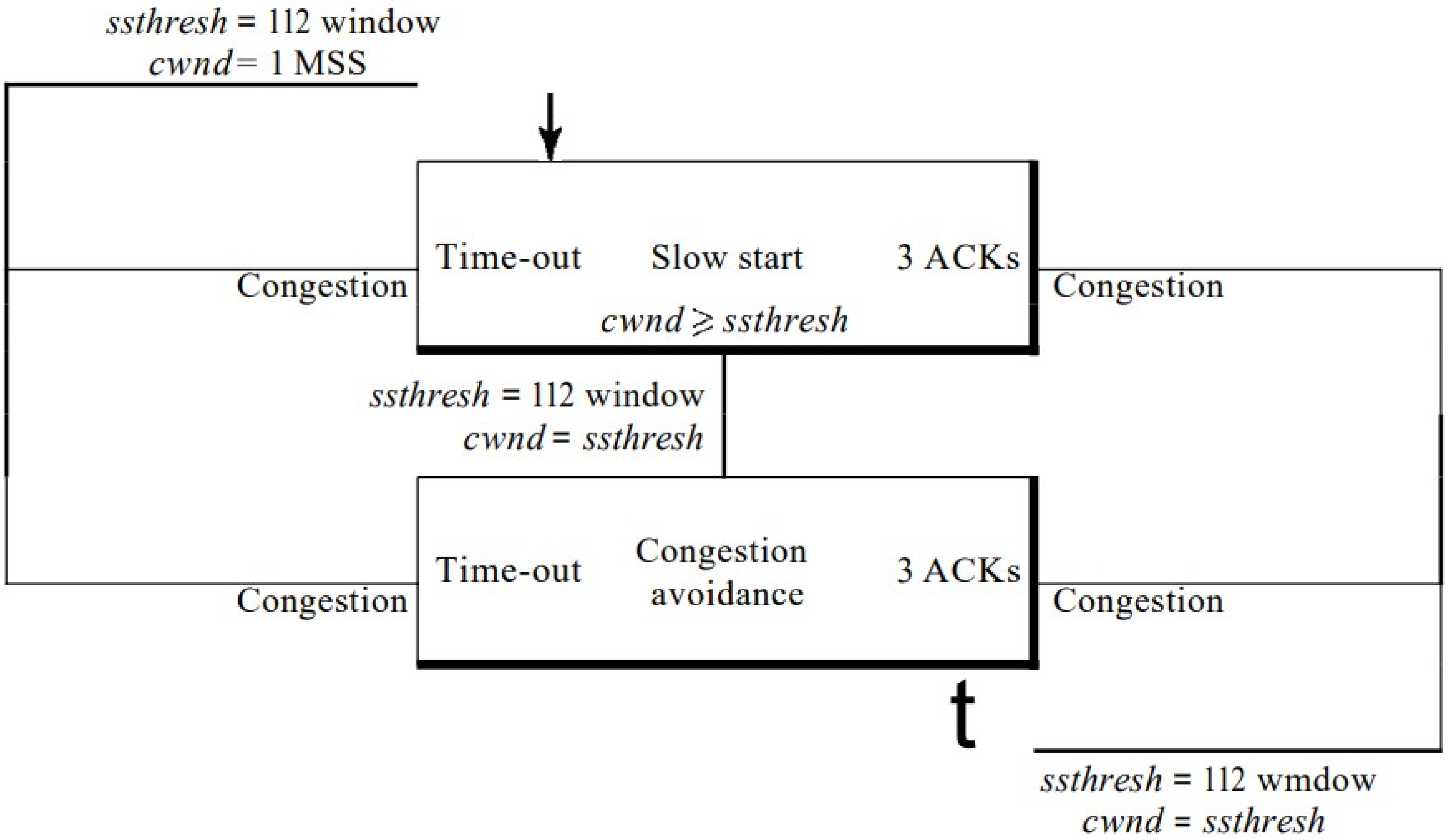
If three ACKs are received, there is a weaker possibility of congestion; a segment may have been dropped, but some segments after that may have arrived safely since three ACKs are received. This is called fast transmission and fast recovery. In this case, TCP has a weaker reaction:

a. It sets the value of the threshold to one-half of the current window size.

b. It sets *cwnd* to the value of the threshold (some implementations add three segment sizes to the threshold).

c. It starts the congestion avoidance phase.

Figure 24.10 *TCP congestion policy summary*



Slow Start

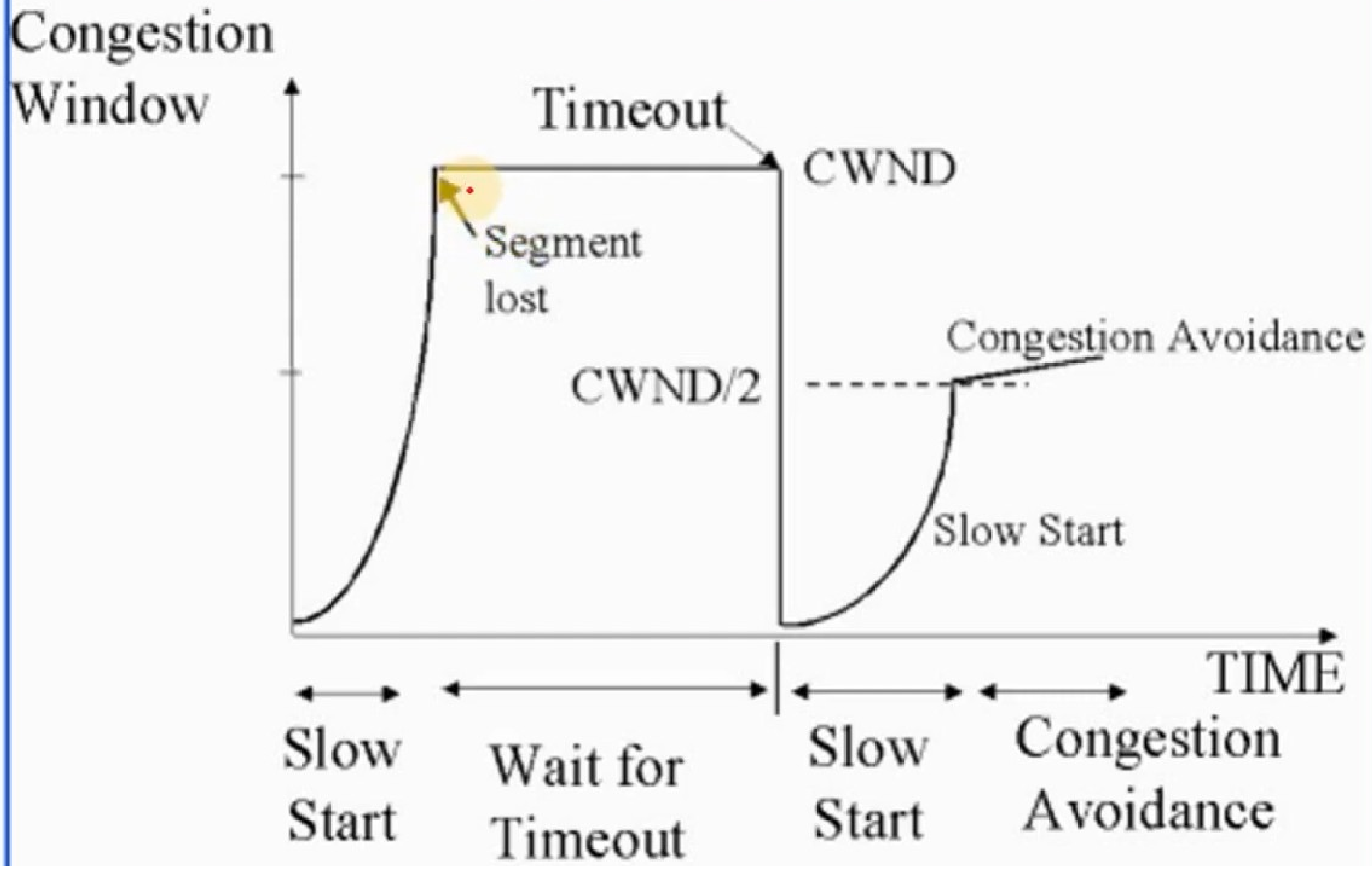
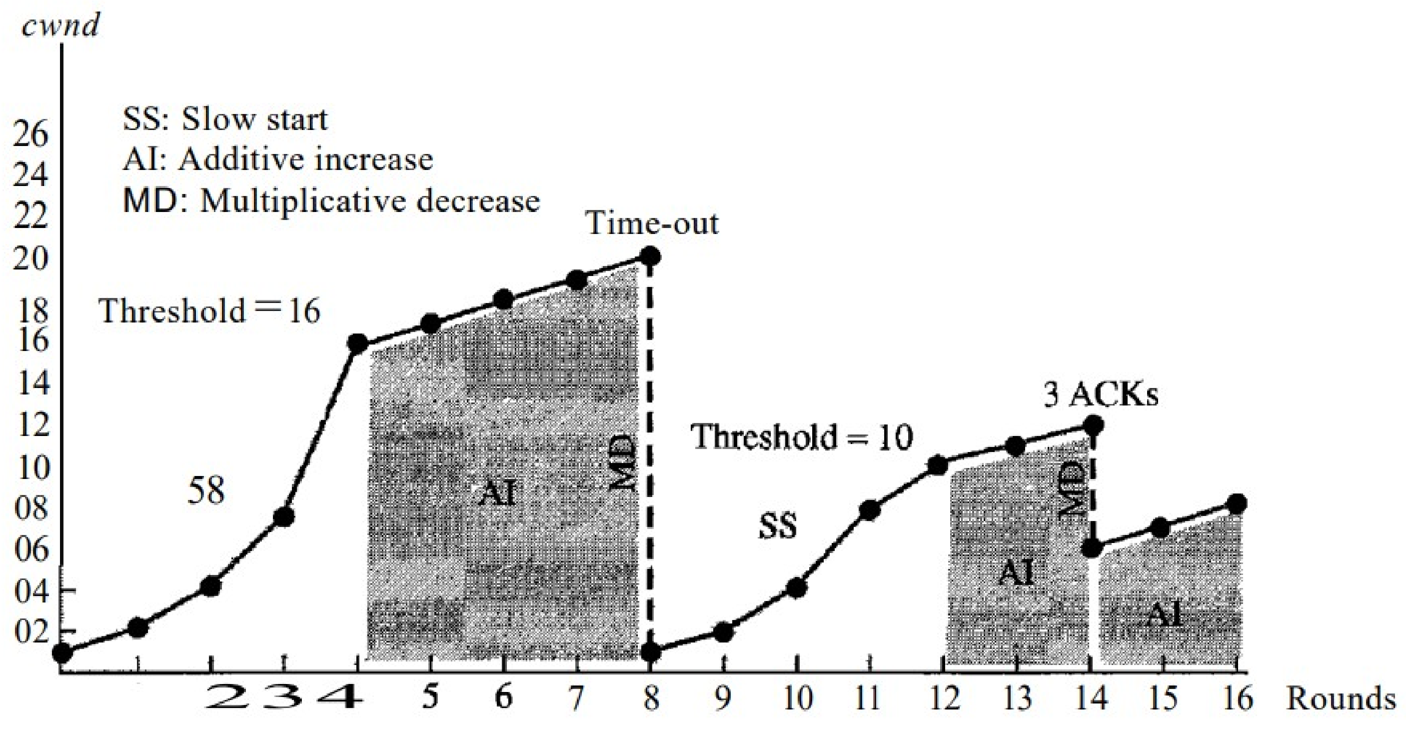

Congestion
Window
Timeout
CWND
Segment
lost
Congestion Avoidance
CWND/2
Slow Start
TIME
Slow
Start
Wait for
Timeout
Slow
Start
Congestion
Avoidance

Figure 24.11 *Congestion example*



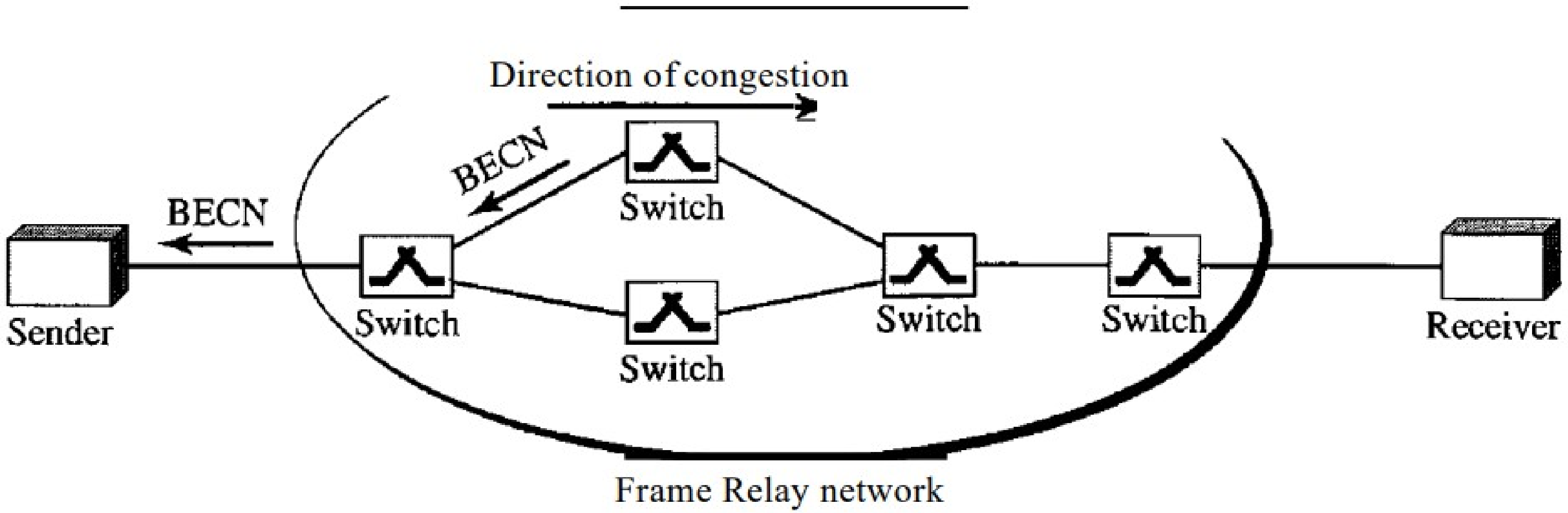
Congestion Control in Frame Relay

- BECN The backward explicit congestion notification (BECN)
- FECN The forward explicit congestion notification (FECN)

BECN

- The backward explicit congestion notification (BECN) bit warns the sender of congestion in the network.
- One might ask how this is accomplished since the frames are traveling away from the sender.
- In fact, there are two methods:
- The switch can use response frames from the receiver (full-duplex mode), or
- Else the switch can use a predefined connection to send special frames for this specific purpose.
- The sender can respond to this warning by simply reducing the data rate.

Figure 24.12 *BECN*



FECN

- The forward explicit congestion notification (FECN) bit is used to warn the receiver of congestion in the network.
- It might appear that the receiver cannot do anything to relieve the congestion.
- However, the Frame Relay protocol assumes that the sender and receiver are communicating with each other and are using some type of flow control at a higher level.
- For example, if there is an acknowledgment mechanism at this higher level, the receiver can delay the acknowledgment, thus forcing the sender to slow down

Figure 24.13 *FECN*

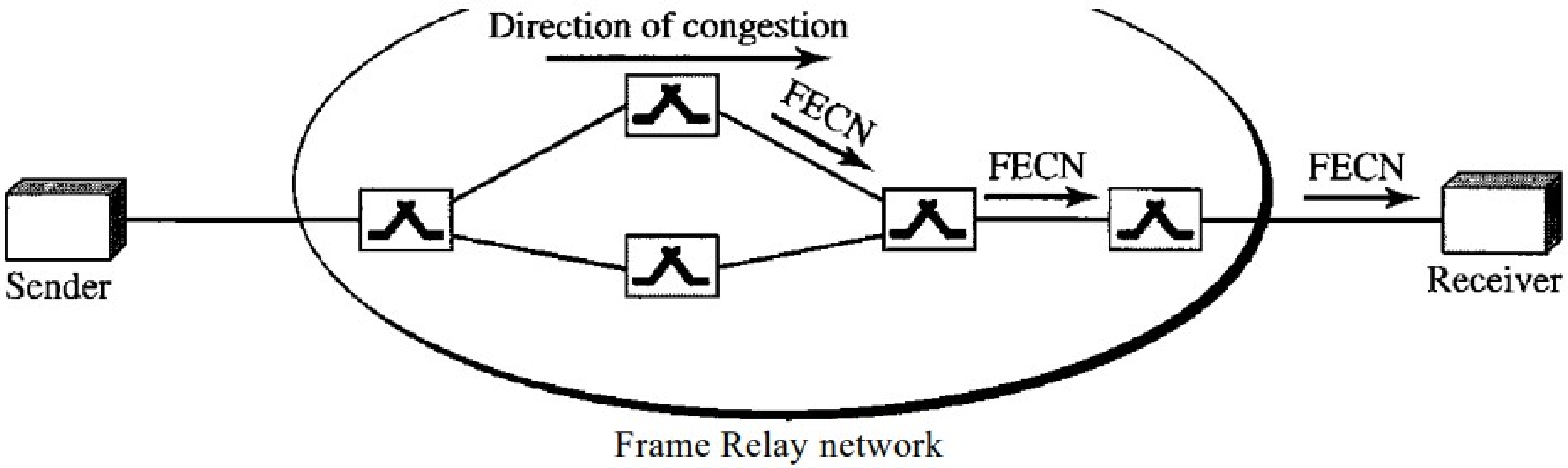
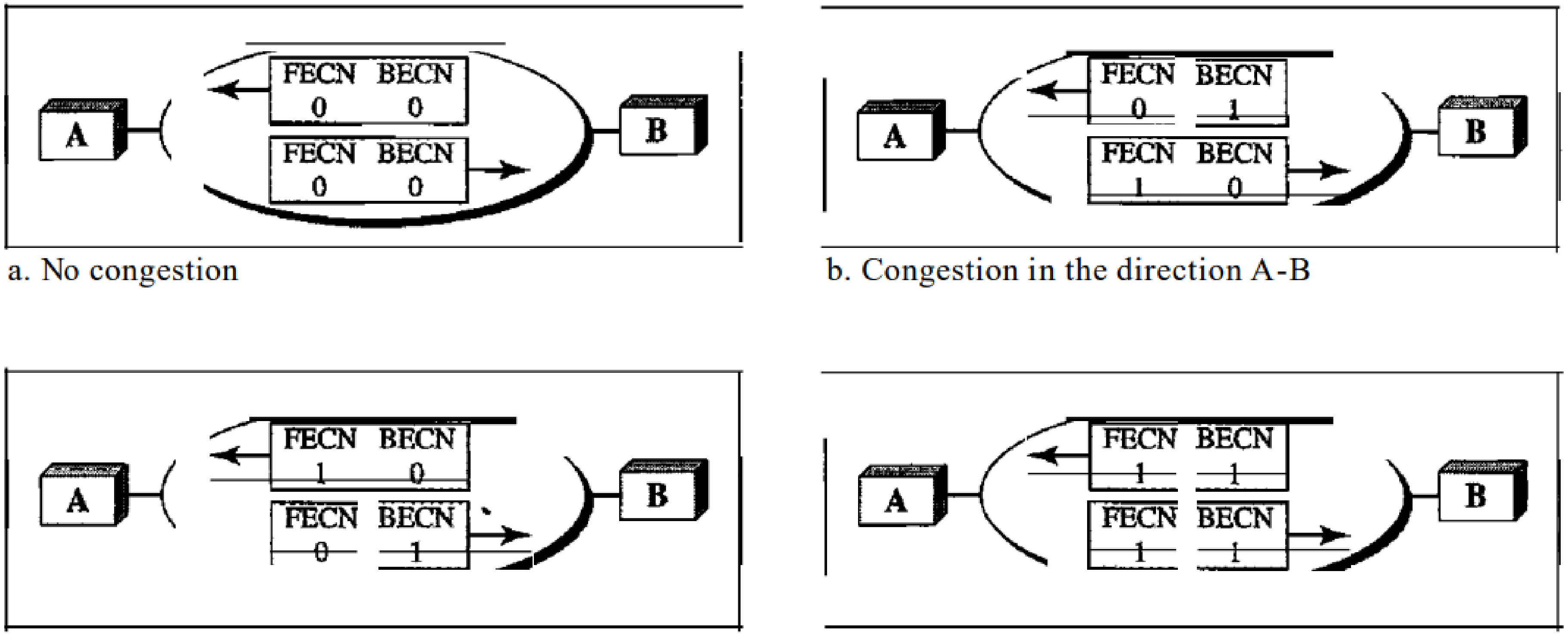


Figure 24.14 *Four cases ofcongestion*



a. No congestion

b. Congestion in the direction A-B

c. Congestion in the direction B-A

d. Congestion in both directions