Transport Layer
Congestion Control

24-1 DATA TRAFFIC

The main focus of congestion control and quality of service is data traffic. In congestion control we try to avoid traffic congestion. In quality of service, we try to create an appropriate environment for the traffic. So, before talking about congestion control and quality of service, we discuss the data traffic itself.

Topics discussed in this section:

Traffic Descriptor
Traffic Profiles

Figure 24.1 *Traffic descriptors*

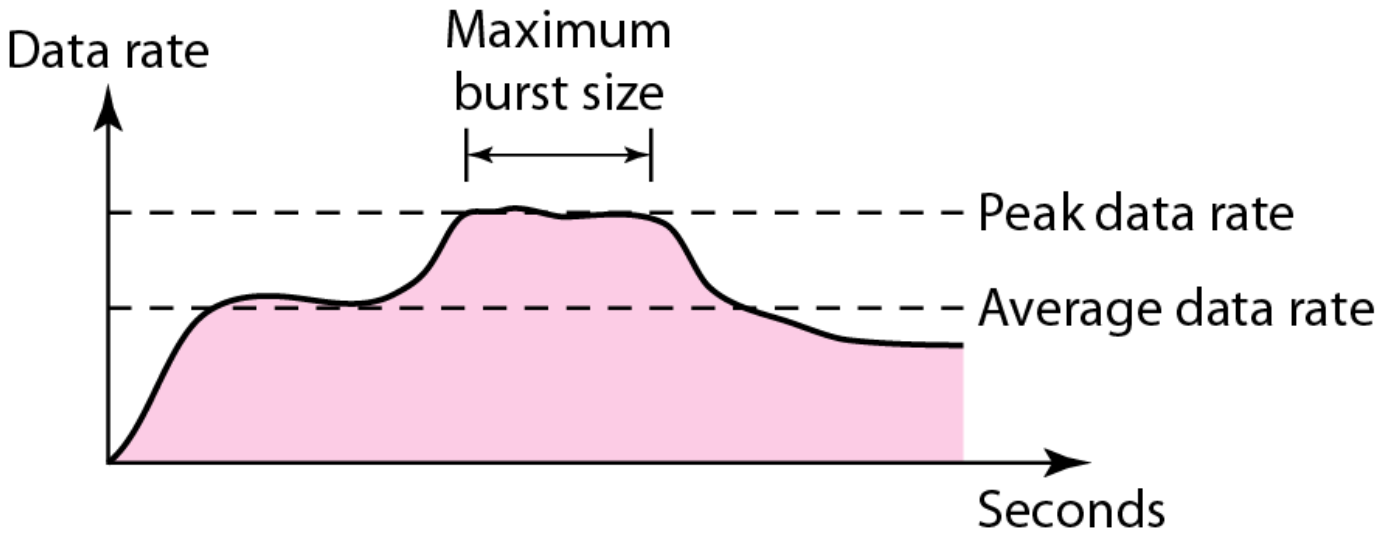
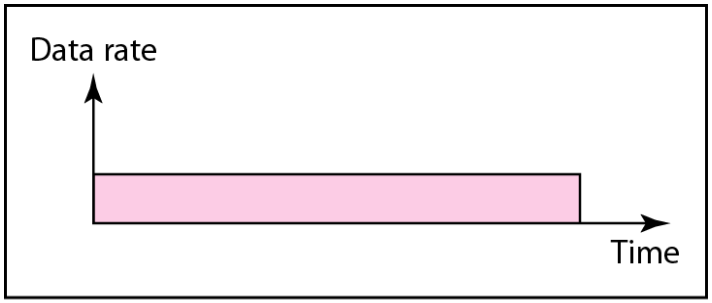
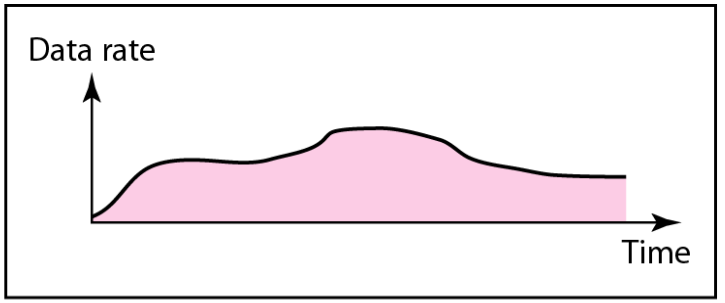


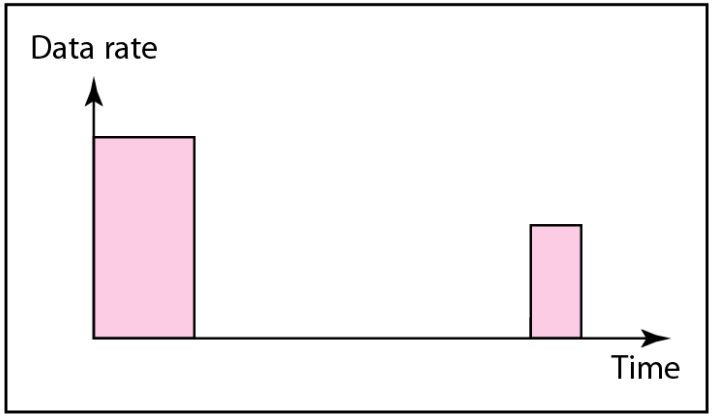
Figure 24.2 *Three traffic profiles*



a. Constant bit rate



b. Variable bit rate



c. Bursty

24-2 CONGESTION

Congestion in a network may occur if the load on the network—the number of packets sent to the network—is greater than the capacity of the network—the number of packets a network can handle. Congestion control refers to the mechanisms and techniques to control the congestion and keep the load below the capacity.

Figure 24.3 *Queues in a router*

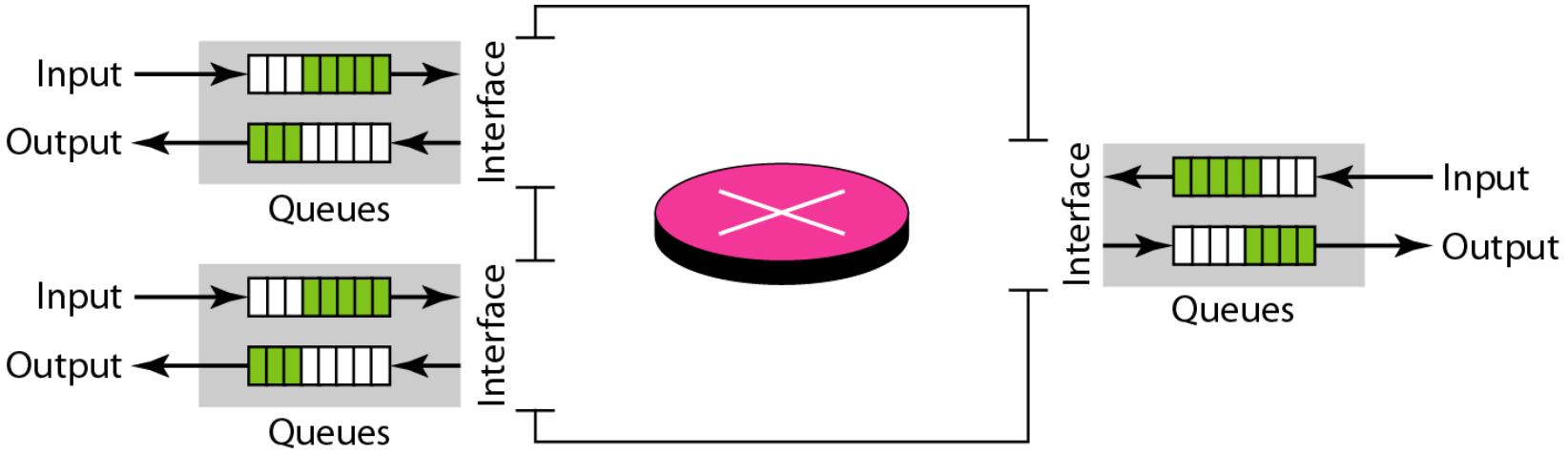
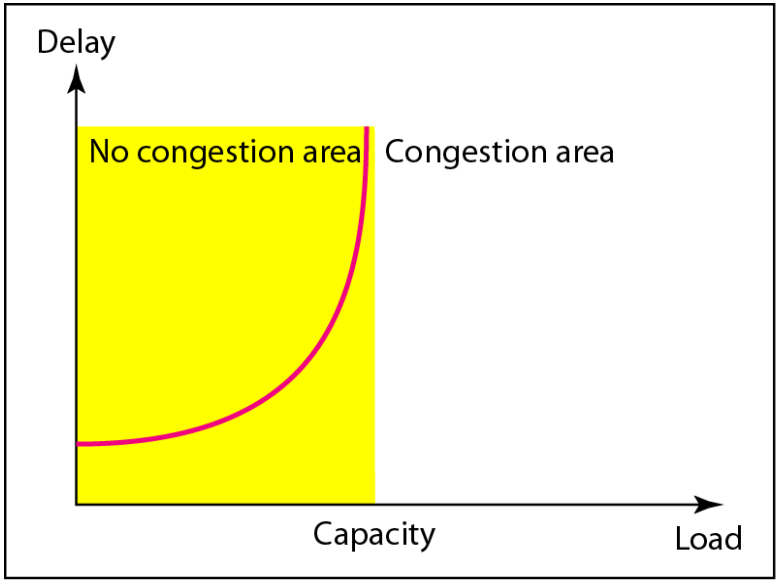
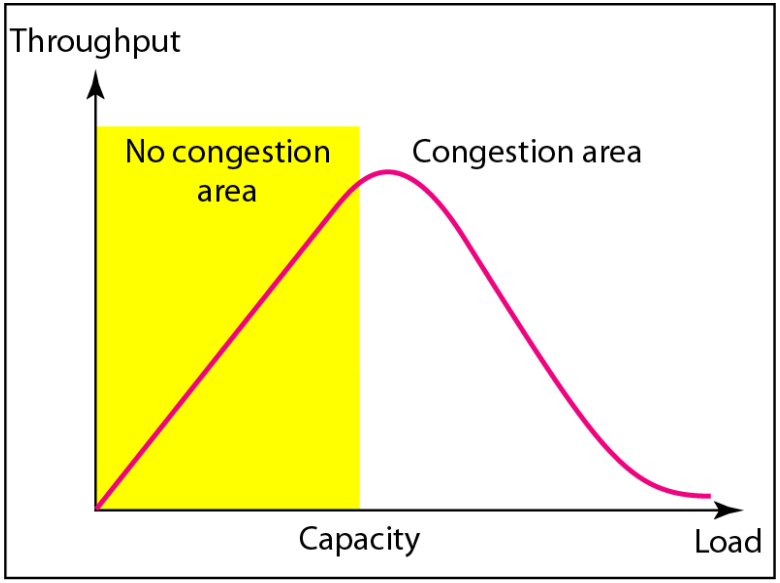


Figure *Packet delay and throughput as functions of load*



a. Delay as a function of load



b. Throughput as a function of load

24-3 CONGESTION CONTROL

Congestion control refers to techniques and mechanisms that can either prevent congestion, before it happens, or remove congestion, after it has happened. In general, we can divide congestion control mechanisms into two broad categories: open-loop congestion control (prevention) and closed-loop congestion control (removal).

Topics discussed in this section:

Open-Loop Congestion Control
Closed-Loop Congestion Control

Figure 24.5 *Congestion control categories*

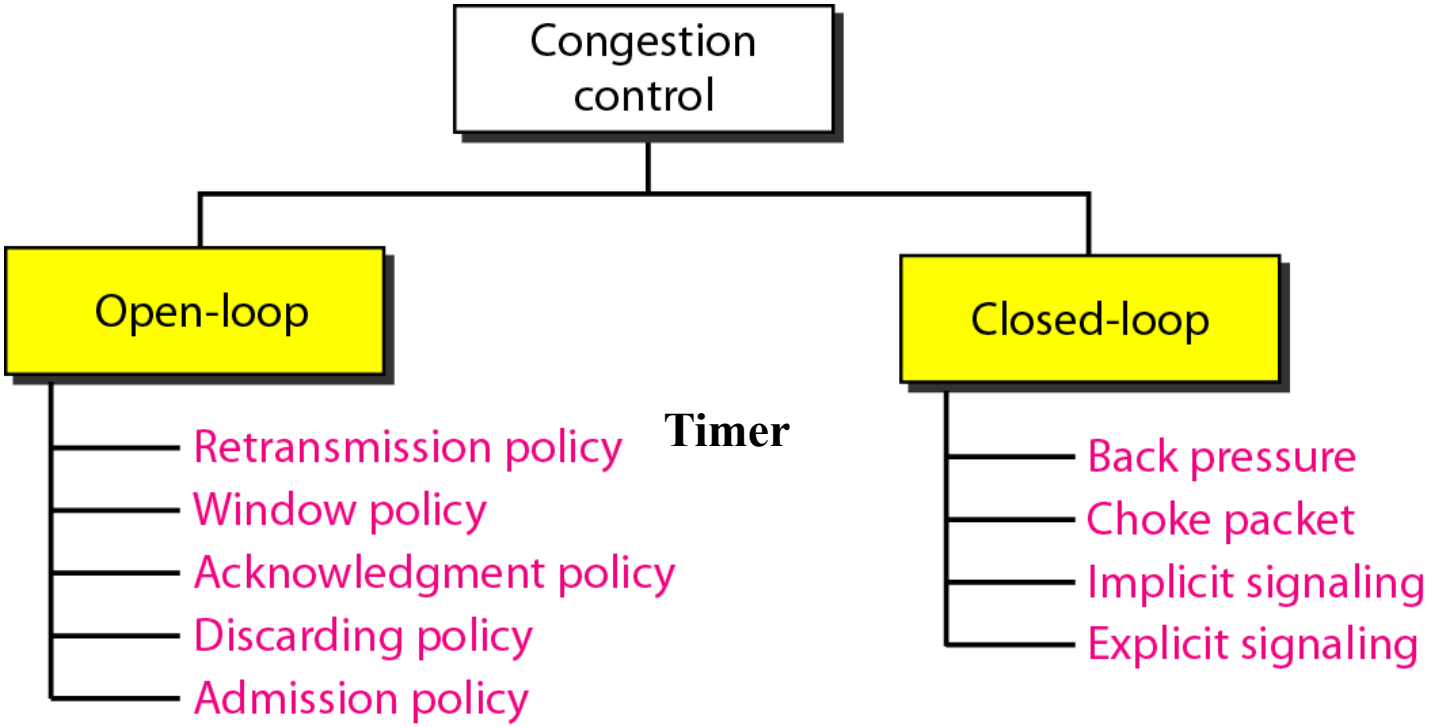


Figure 24.6 *Backpressure method for alleviating congestion*

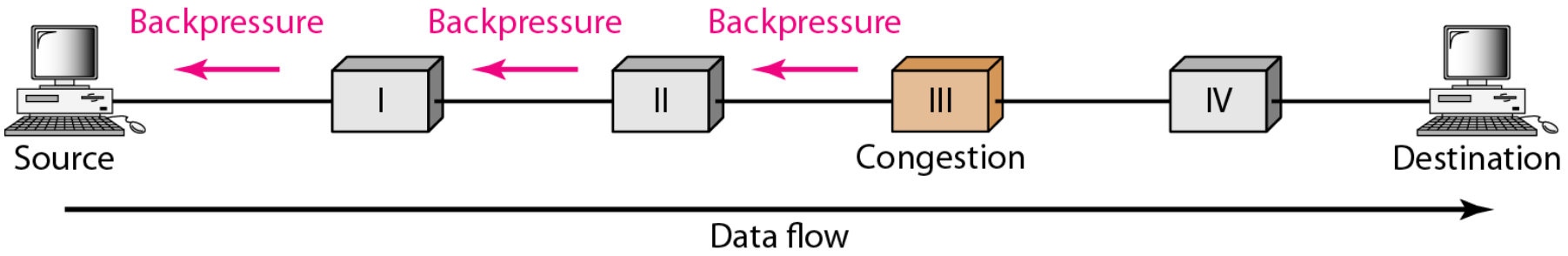
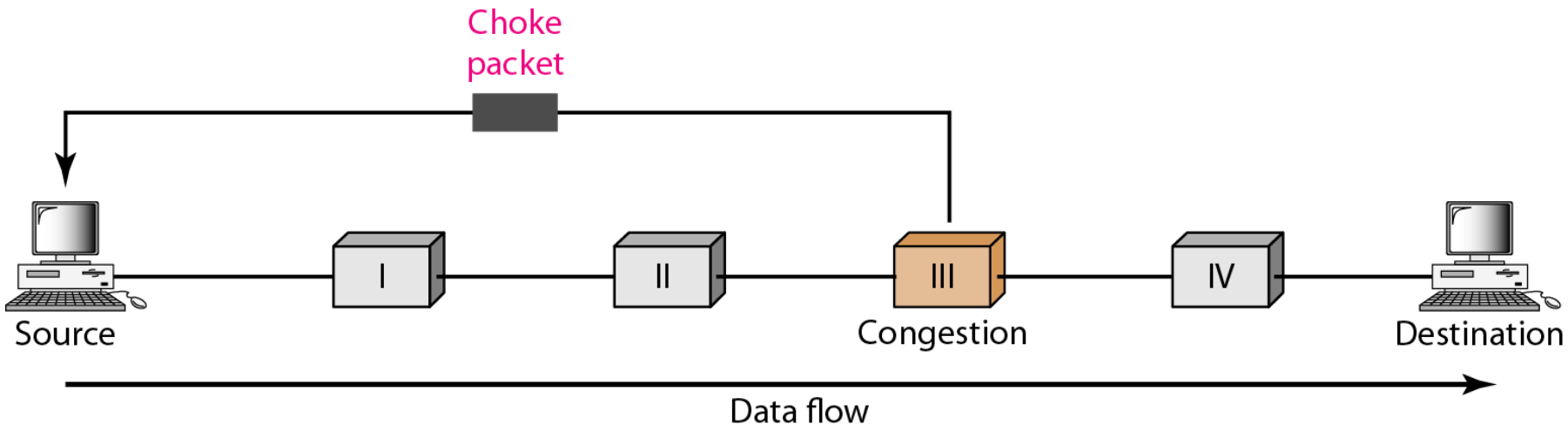


Figure 24.7 *Choke packet*



Implicit and Explicit Signaling

- Implicit Signaling
  - by symptoms source will identify or assume congestion in the network.
- Explicit Signaling
  - Node will send a message to source or destination notifying congestion in the network
  - Backward signaling
  - Forward signalling

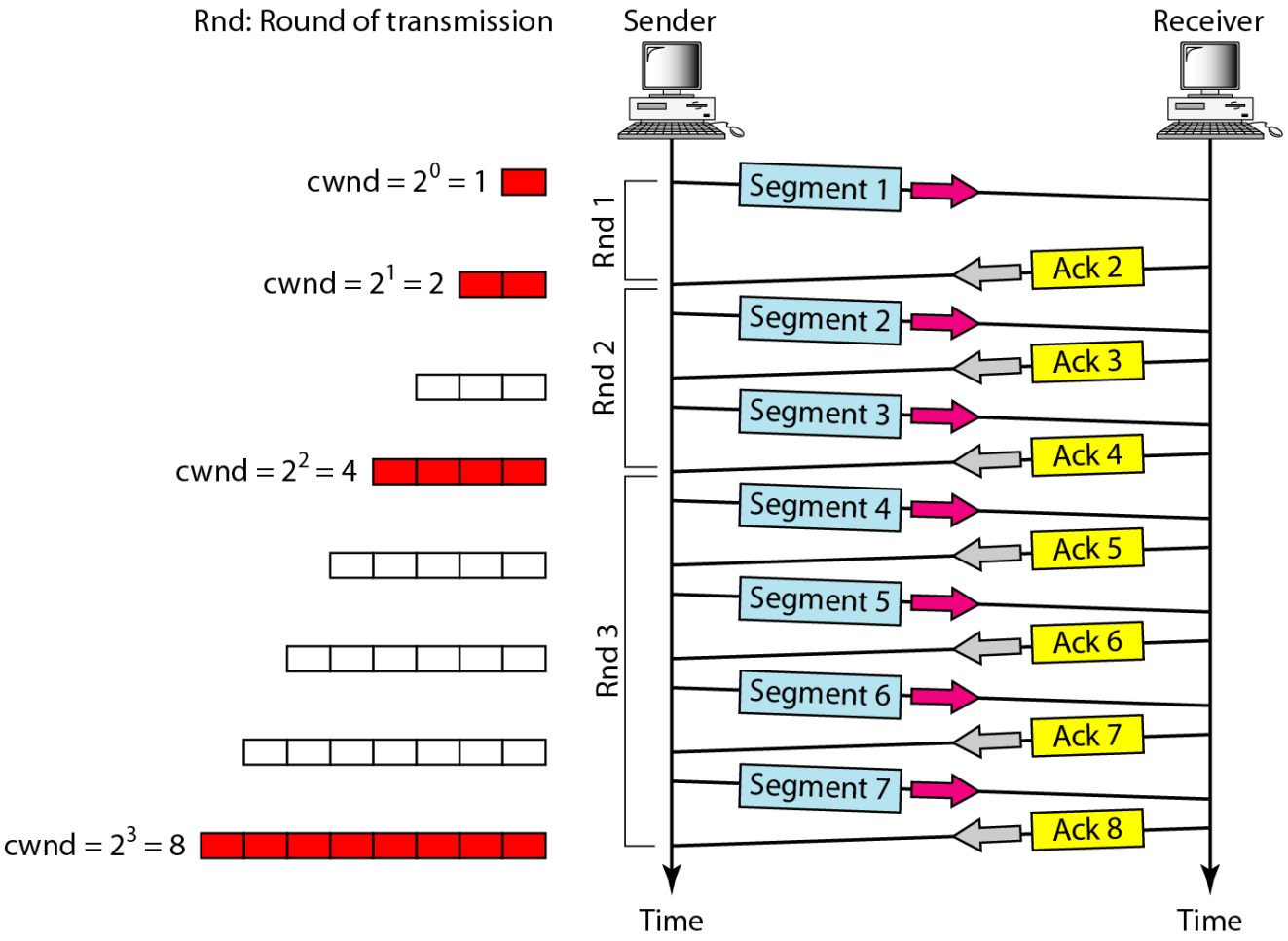
24-4 TWO EXAMPLES

To better understand the concept of congestion control, let us give two examples: one in TCP and the other in Frame Relay.

Topics discussed in this section:

Congestion Control in TCP
Congestion Control in Frame Relay

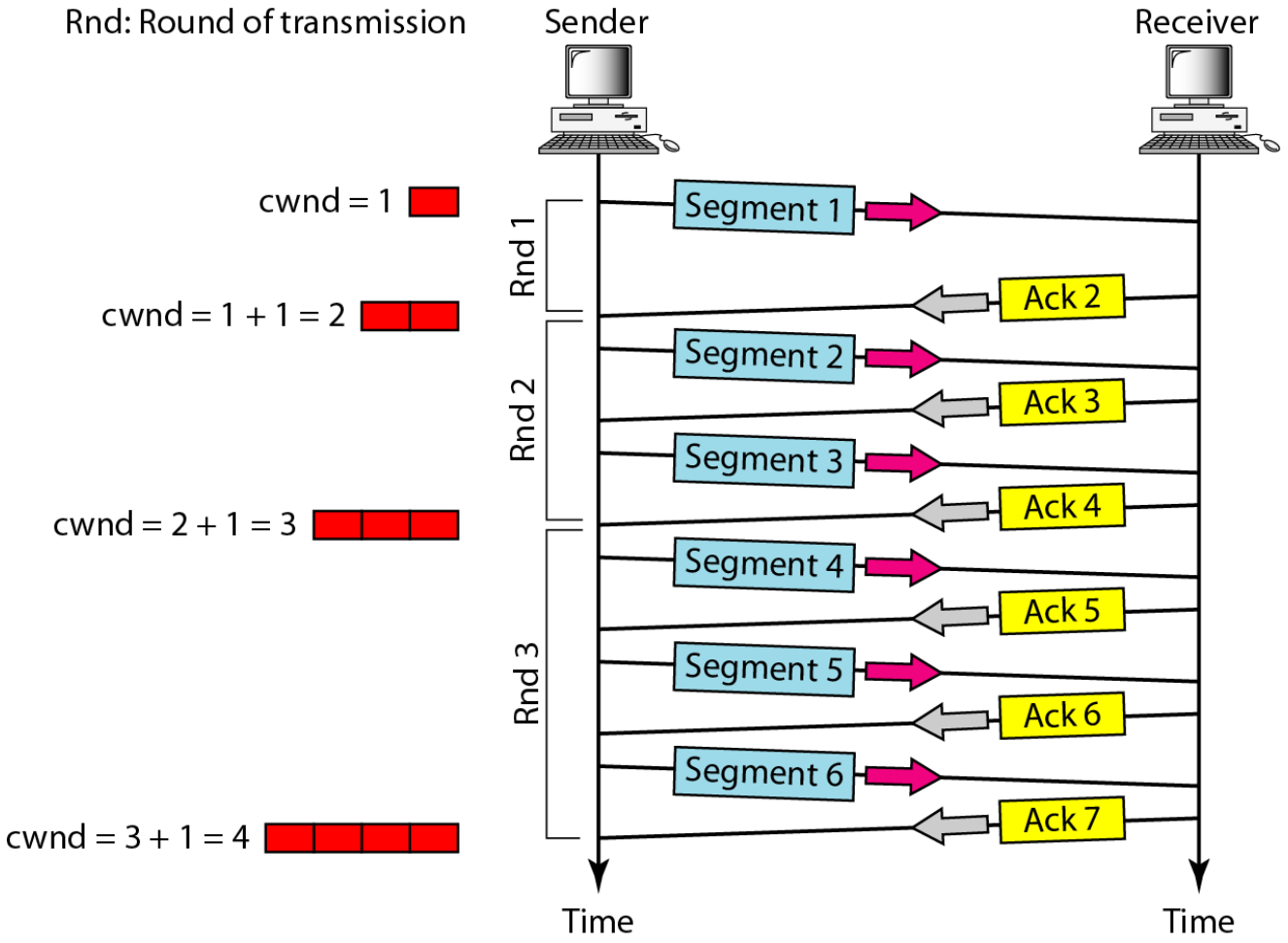
Figure 24.8 *Slow start, exponential increase*



Note

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

Figure 24.9 *Congestion avoidance, additive increase*



Note

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

An implementation reacts to congestion detection in one of the following ways:

- If detection is by time-out, a new slow start phase starts.
- If detection is by three ACKs, a new congestion avoidance phase starts.

Due to time-out

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.

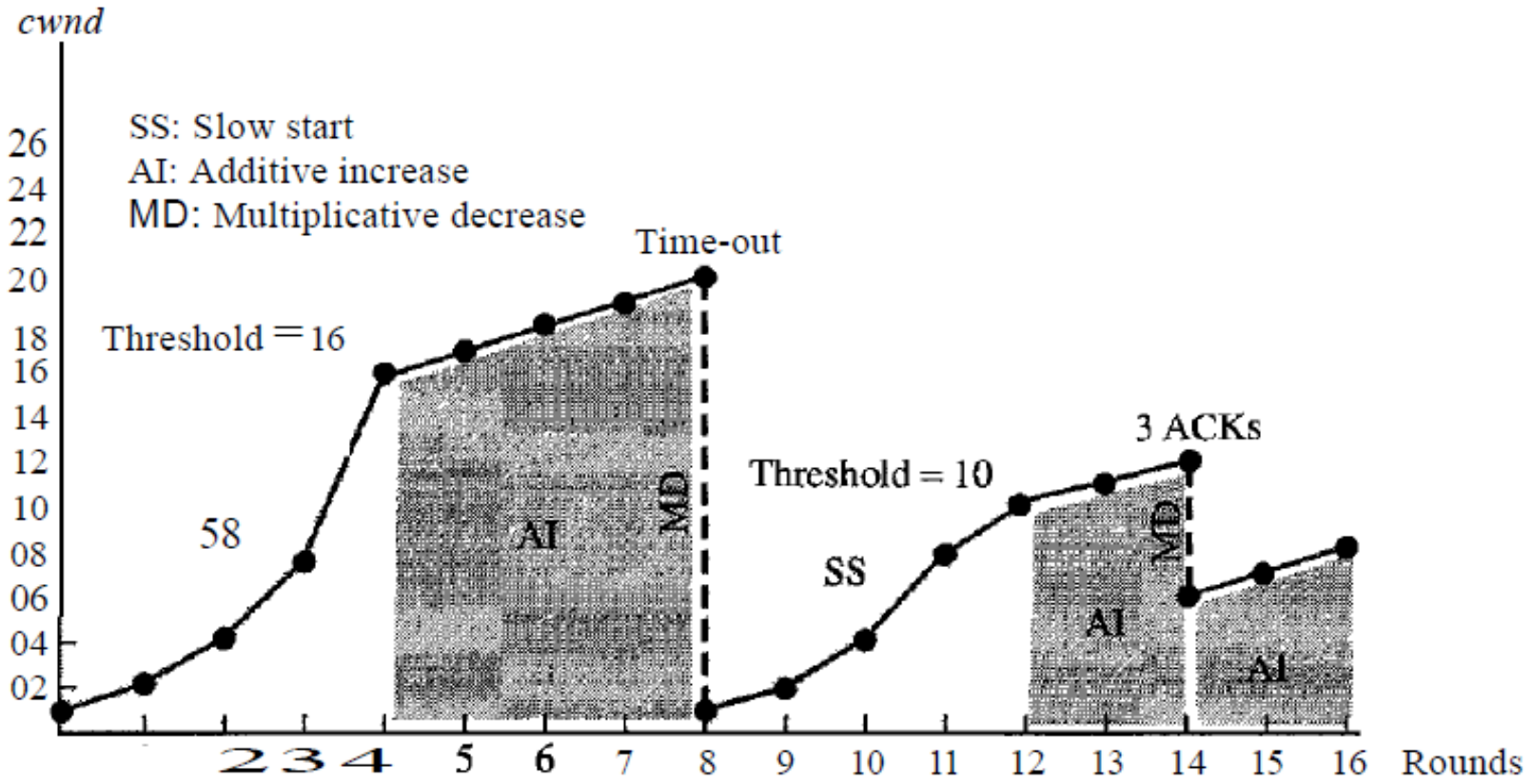
c. It starts the slow-start phase again.

Due to 3 duplicate acknowledgements

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.


cwnd
SS: Slow start
AI: Additive increase
MD: Multiplicative decrease
Time-out
Threshold = 16
Threshold = 10
3 ACKs
58
SS
AI
MD
AI
MD
AI
26
24
22
20
18
16
14
12
10
08
06
04
02
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Rounds

TCP Delay Modelling

- How long does it take to receive an object from a HTTP server after sending a request?
- If we ignore congestion, delay is influenced by:
  - TCP connection establishment
  - Data transmission delay
  - Slow start