Data Communications and Networking Fourth Edition

Forouzan

Congestion Control and Quality of Service

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.

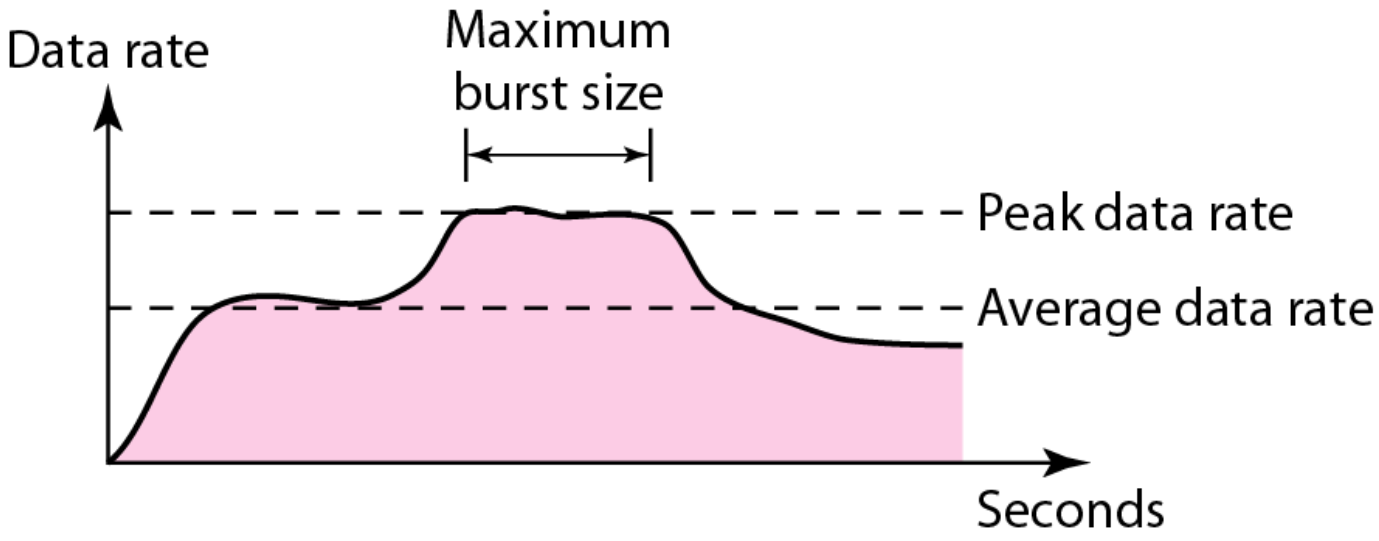
Topics discussed in this section:

Traffic Descriptor

Traffic Profiles

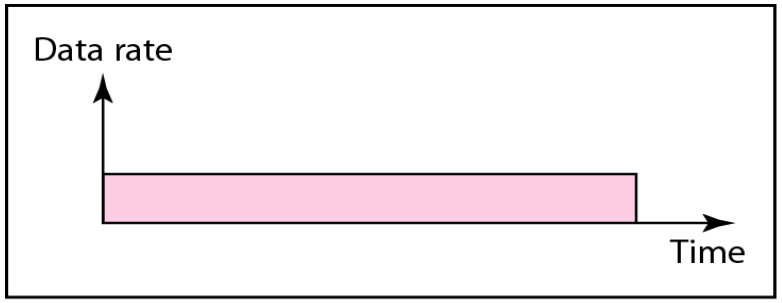
Figure *Traffic descriptors*

Traffic descriptors are qualitative values that represent a data flow.

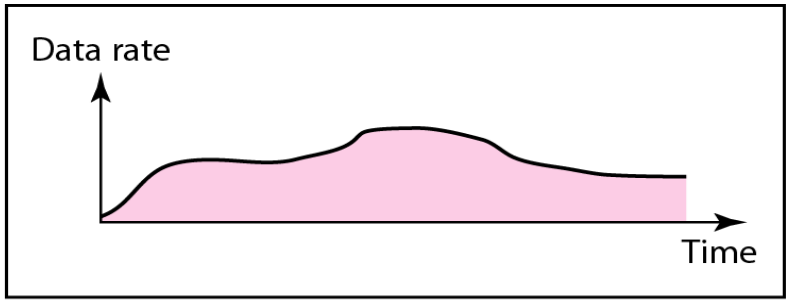


The maximum burst size normally refers to the maximum length of time the traffic is generated at the peak rate.

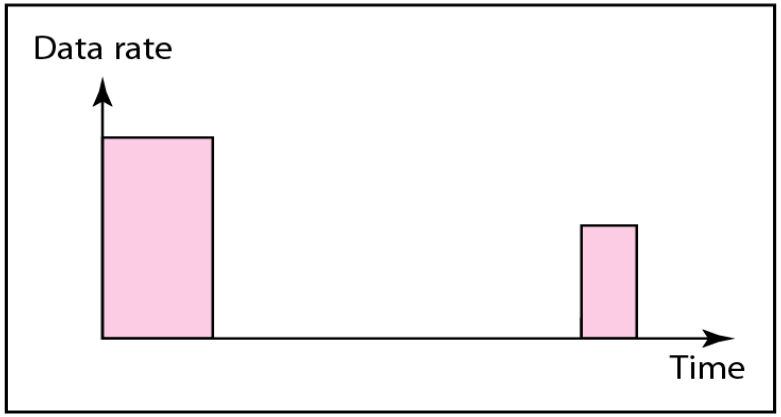
Figure *Three traffic profiles*



a. Constant bit rate



b. Variable bit rate



c. Bursty

In bursty data category data rate changes suddenly w.r.t time.

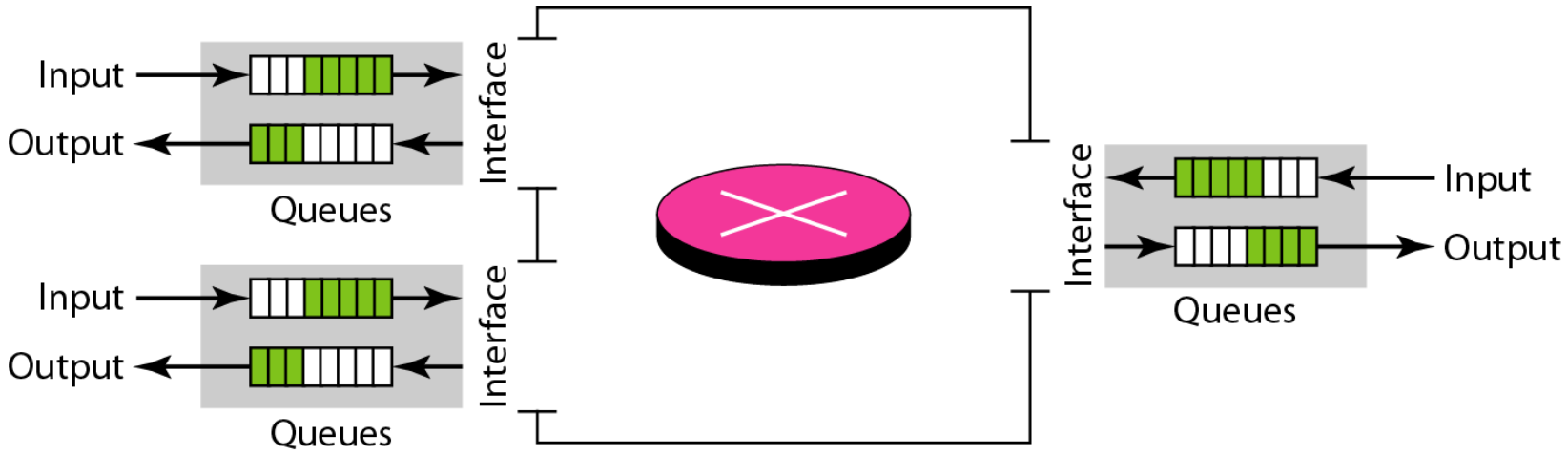
CONGESTION

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.

Topics discussed in this section:

Network Performance

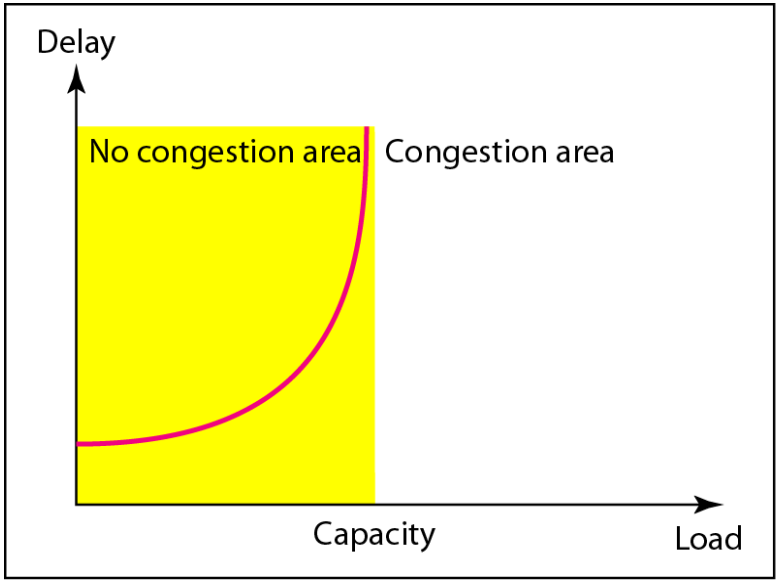
Figure *Queues in a router*



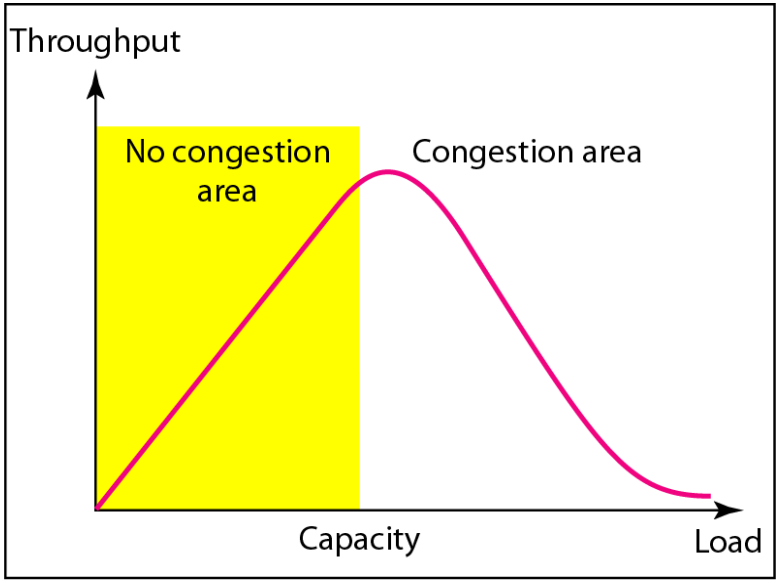
1. The packet is put at the end of the input queue while waiting to be checked.
2. The processing module of the router removes the packet from the input queue once it reaches the front of the queue and uses its routing table and the destination address to find the route.
3. The packet is put in the appropriate output queue and waits till its turn to be sent.

Figure *Packet delay and throughput as functions of load*

Congestion control involves two factors that measure the performance of a network. Delay and Throughput



a. Delay as a function of load



b. Throughput as a function of load

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 *Congestion control categories*

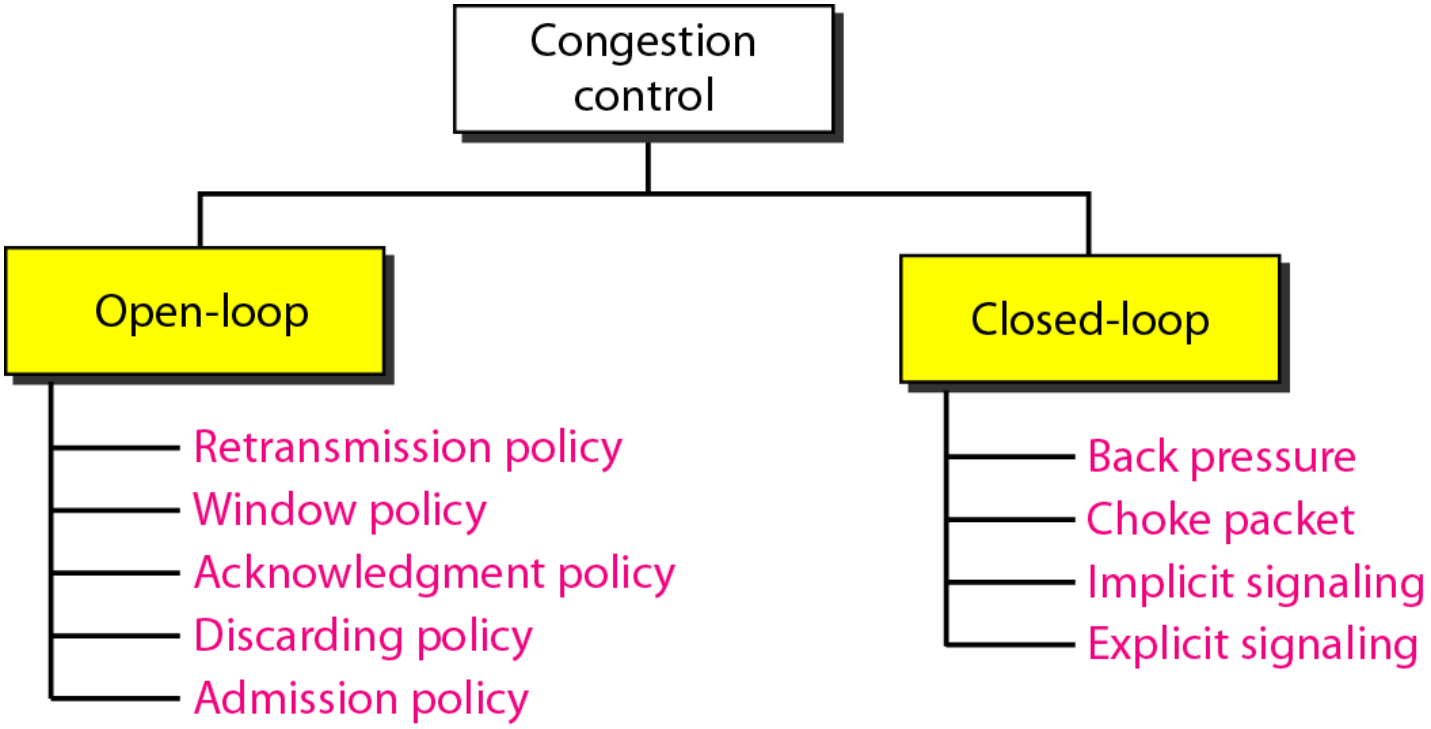


Figure *Backpressure method for alleviating congestion*

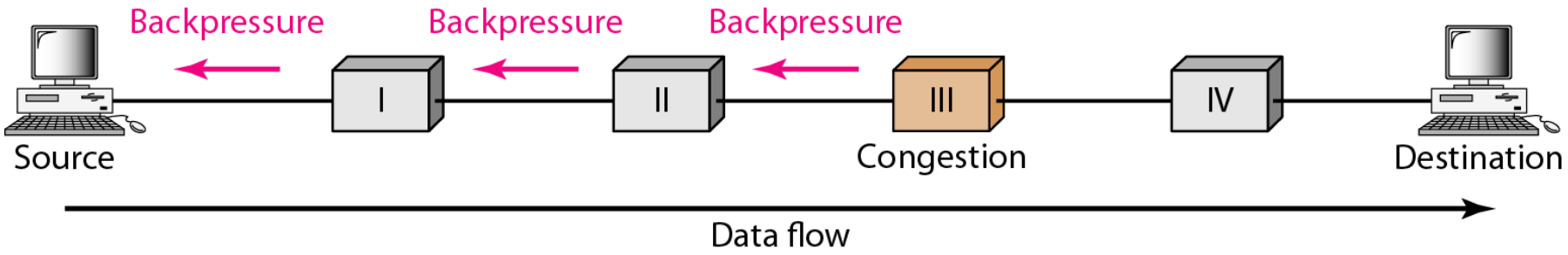
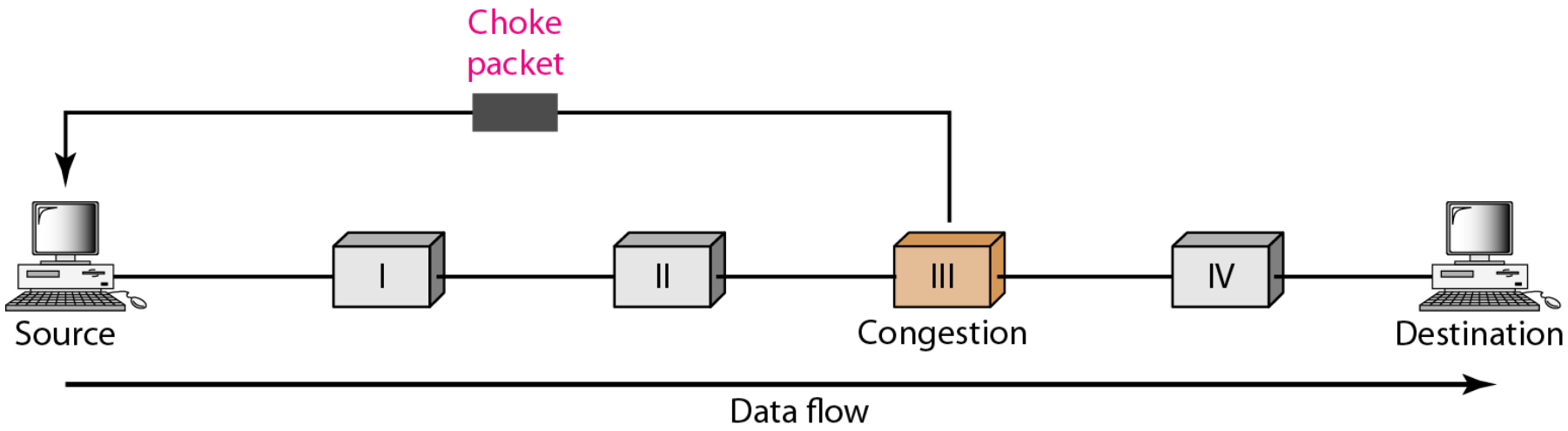


Figure *Choke packet*



TWO EXAMPLES

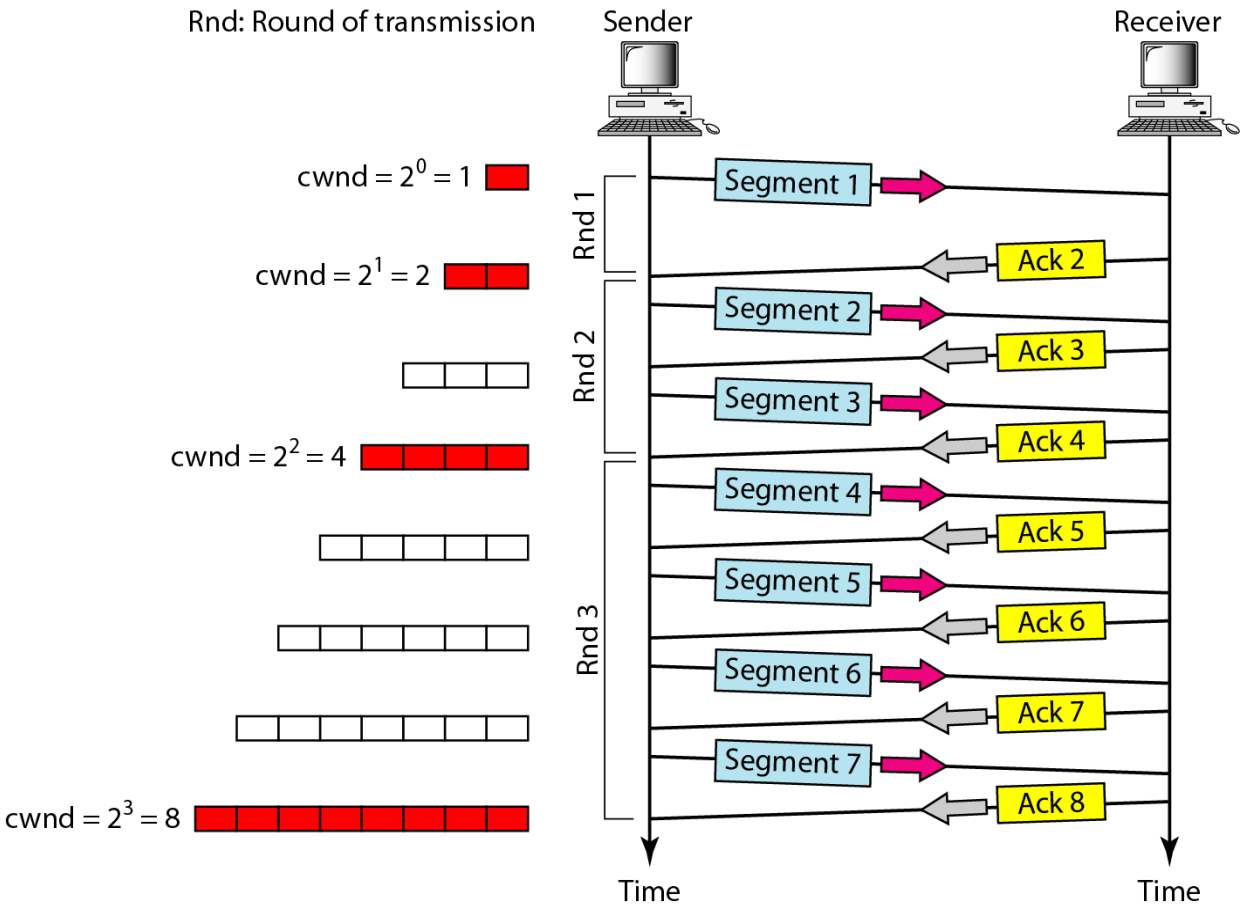
To better understand the concept of congestion control, let us give two examples: one in TCP and the other in Frame Relay.

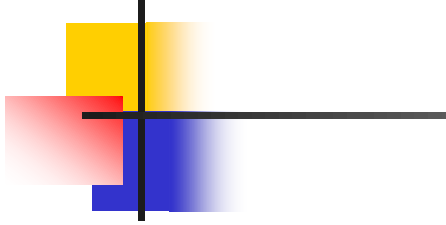
Topics discussed in this section:

Congestion Control in TCP

Congestion Control in Frame Relay

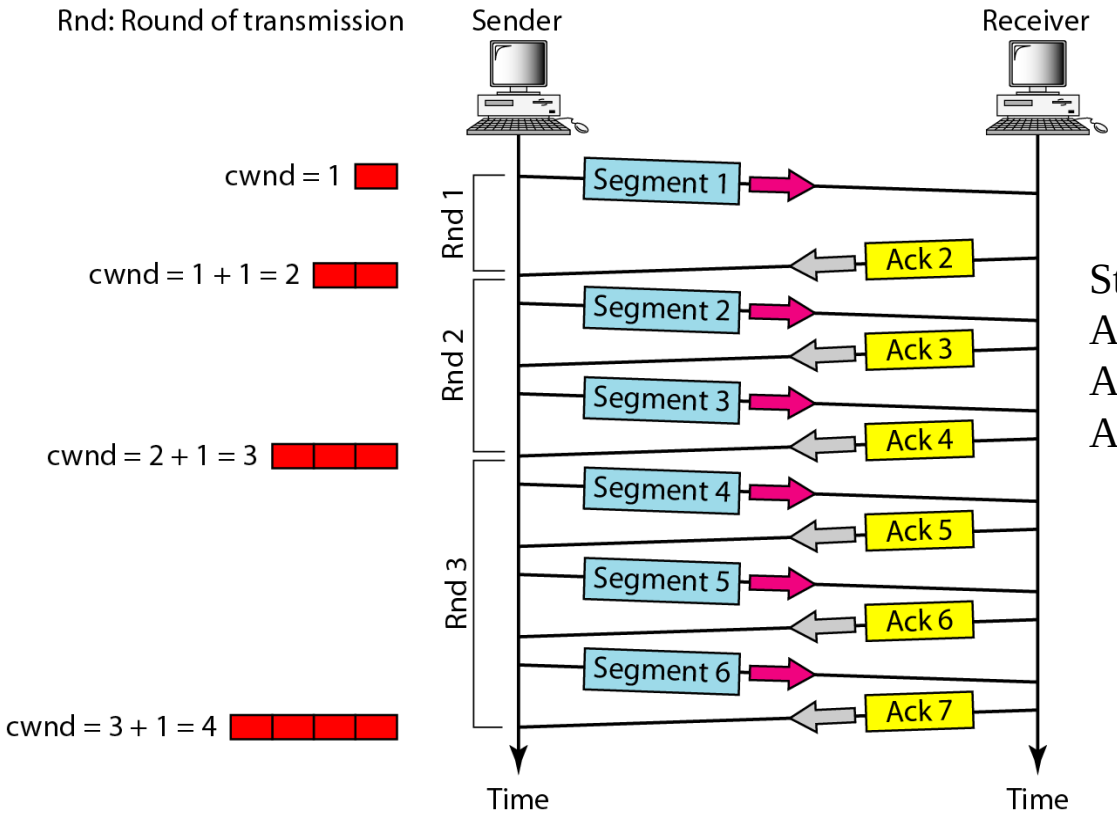
Figure *Slow start, exponential increase*





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

Figure *Congestion avoidance, additive increase*



Start ..... *cwnd=l*
After round 1 ..... $cwnd=2^1=2$
After round 2 ..... $cwnd=2^2=4$
After round 3 ..... $cwnd=2^3=8$

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

Figure *BECN*

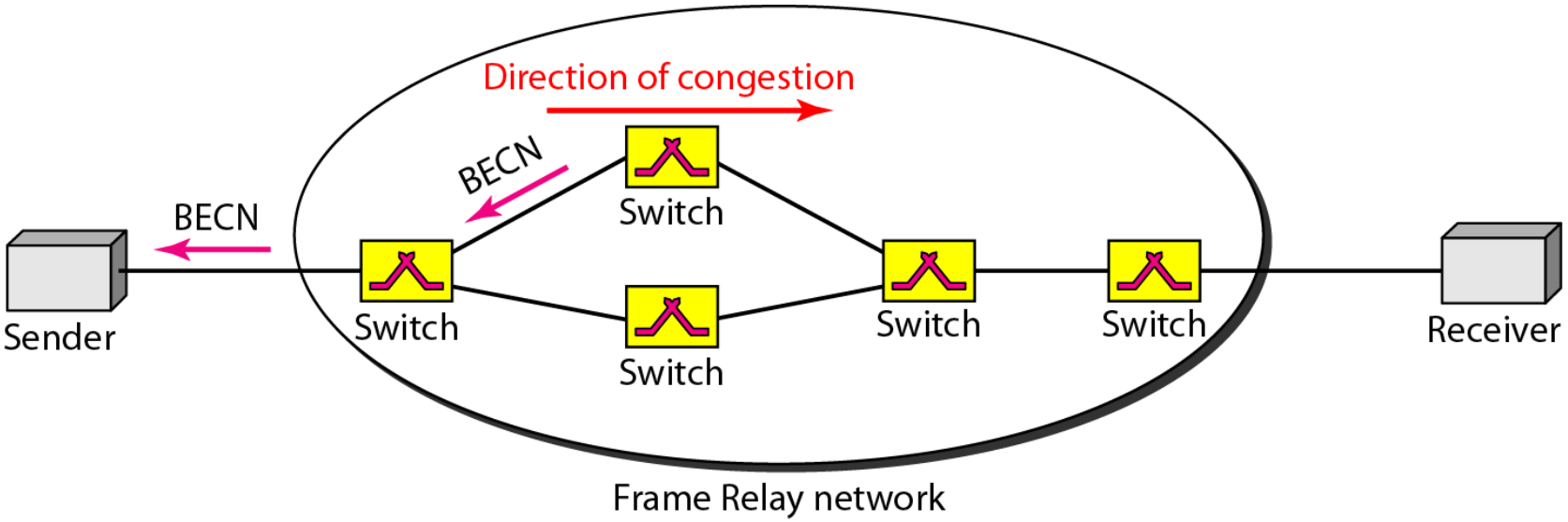

Direction of congestion
BECN
BECN
Switch
Switch
Switch
Switch
Switch
Sender
Receiver
Frame Relay network

Figure *FECN*

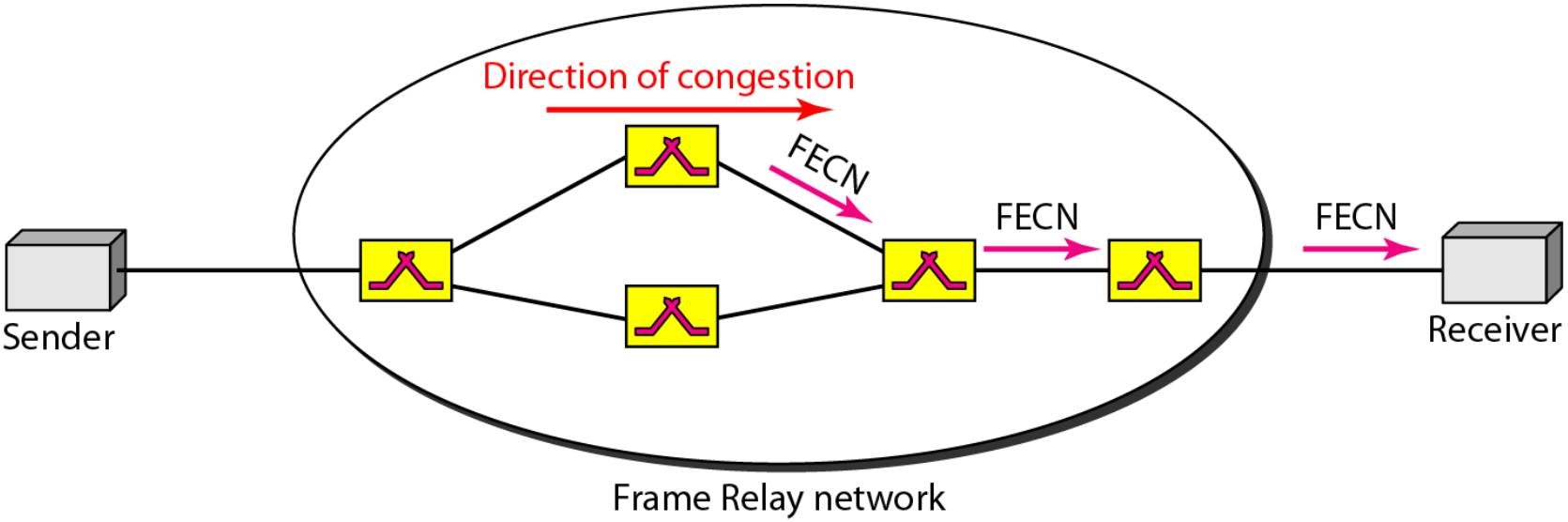
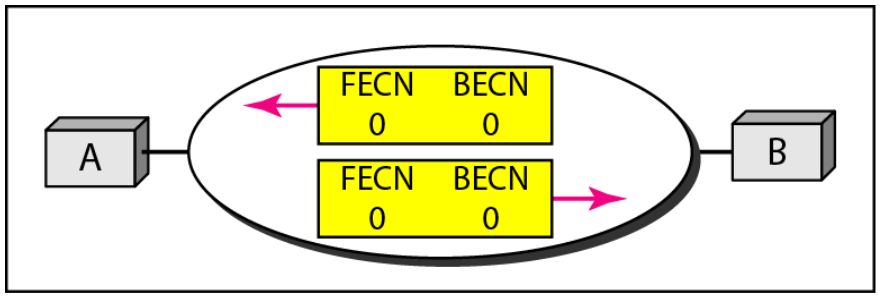
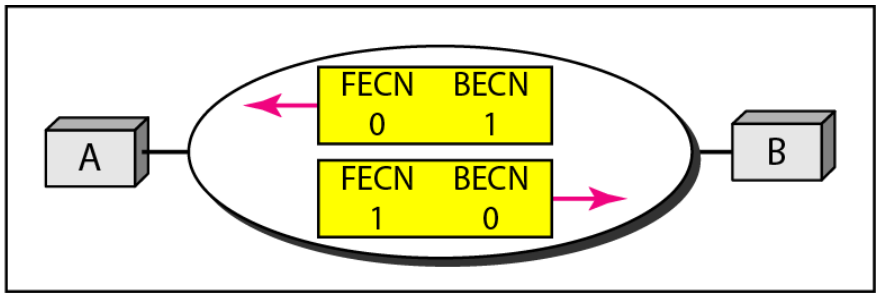

Direction of congestion
FECN
FECN
FECN
Sender
Receiver
Frame Relay network

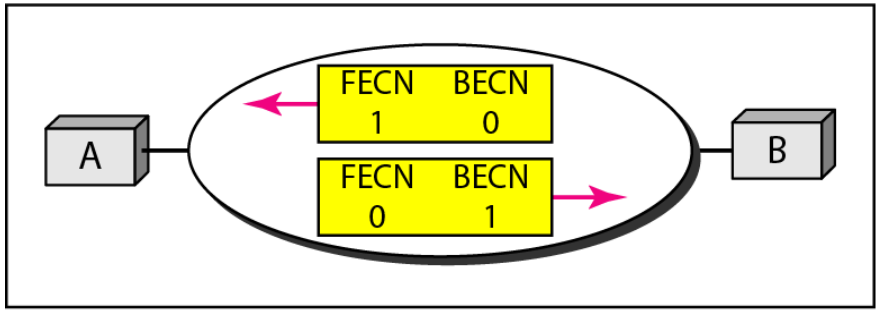
Figure *Four cases of congestion*



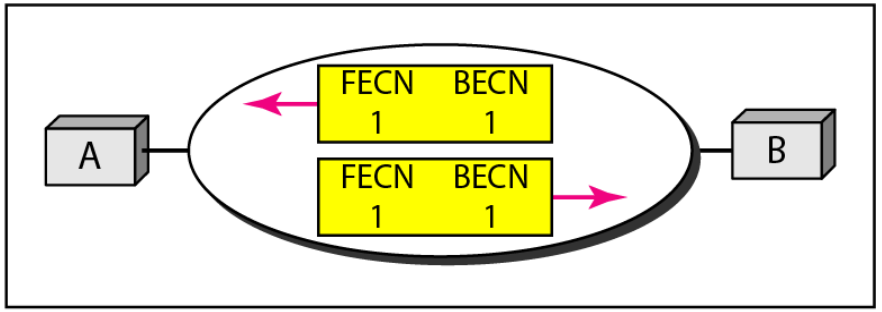
a. No congestion



b. Congestion in the direction A–B



c. Congestion in the direction B–A



d. Congestion in both directions

QUALITY OF SERVICE

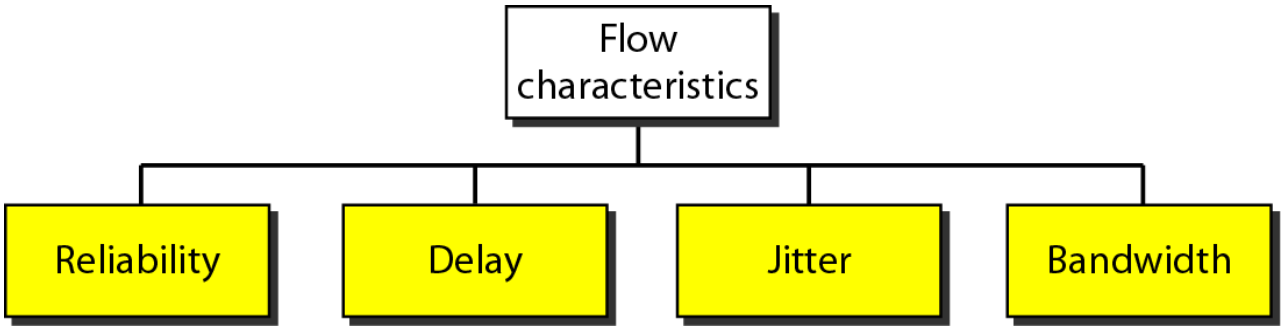
Quality of service (QoS) is an internetworking issue that has been discussed more than defined. We can informally define quality of service as something a flow seeks to attain.

Topics discussed in this section:

Flow Characteristics

Flow Classes

Figure *Flow characteristics*



TECHNIQUES TO IMPROVE QoS

We tried to define QoS in terms of its characteristics. In this section, we discuss some techniques that can be used to improve the quality of service. We briefly discuss four common methods: scheduling, traffic shaping, admission control, and resource reservation.

Topics discussed in this section:

Scheduling
Traffic Shaping
Resource Reservation
Admission Control

Figure *FIFO queue*

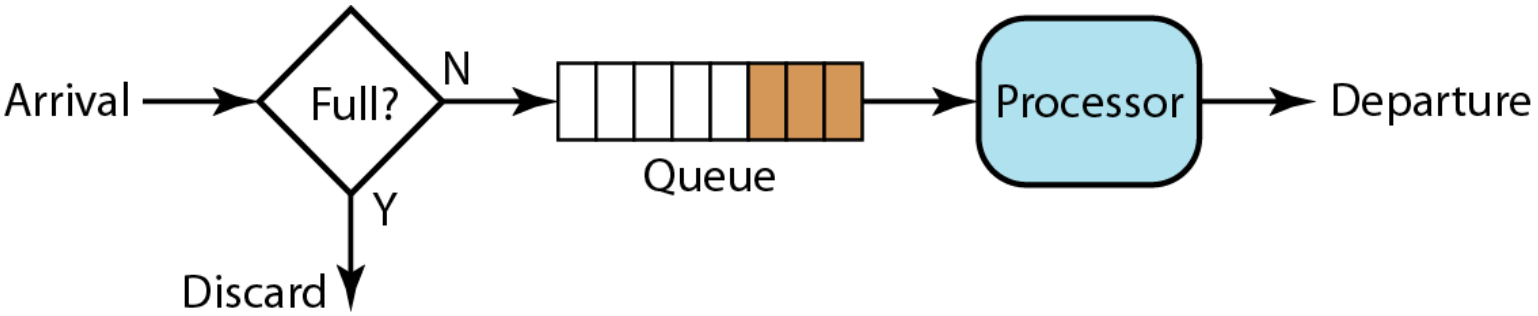


Figure *Priority queuing*

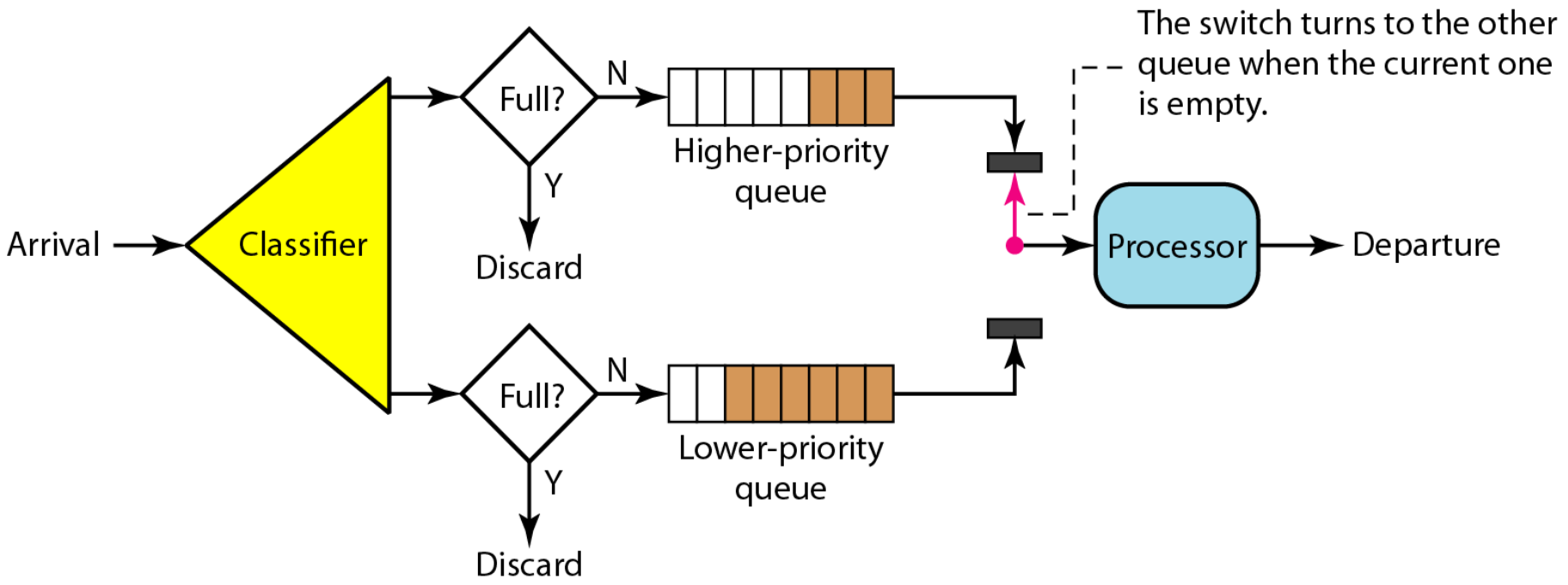


Figure *Weighted fair queuing*

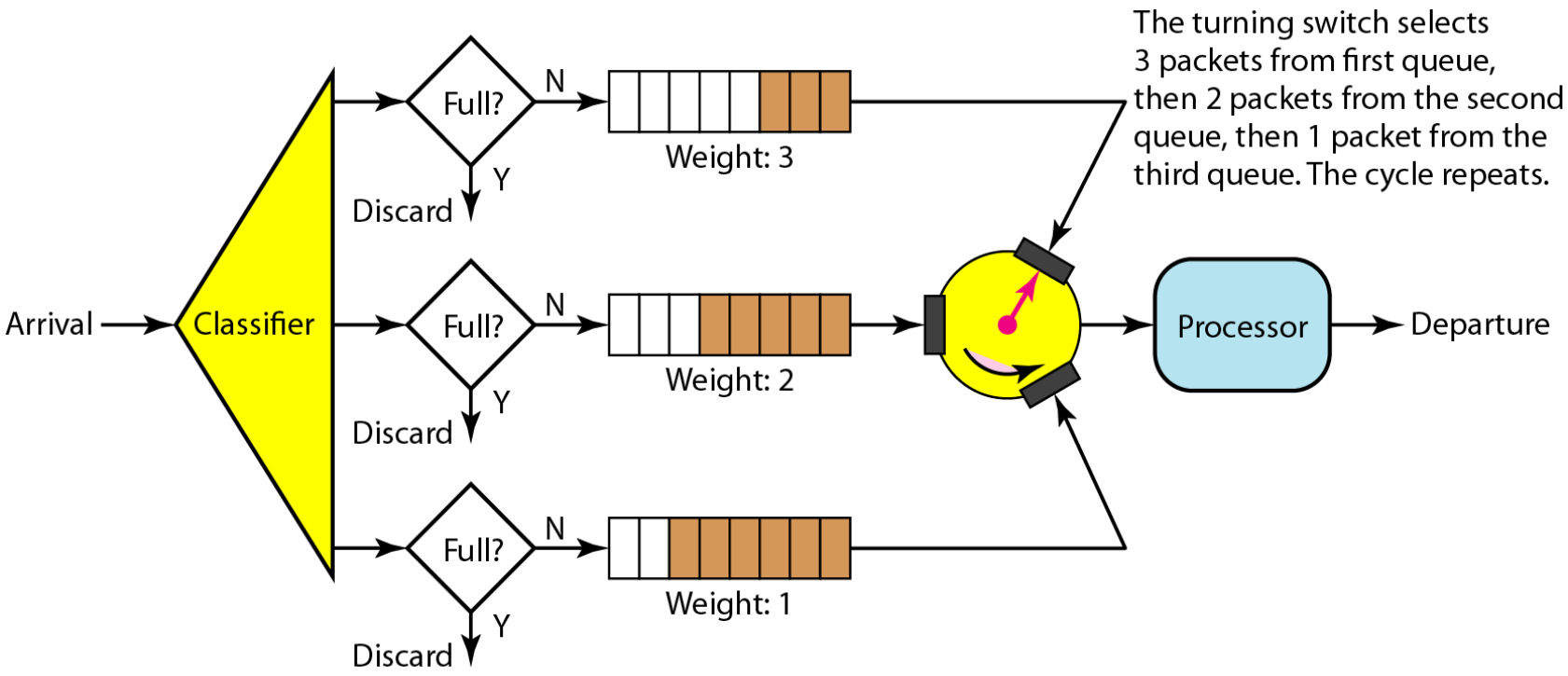


Figure *Leaky bucket*

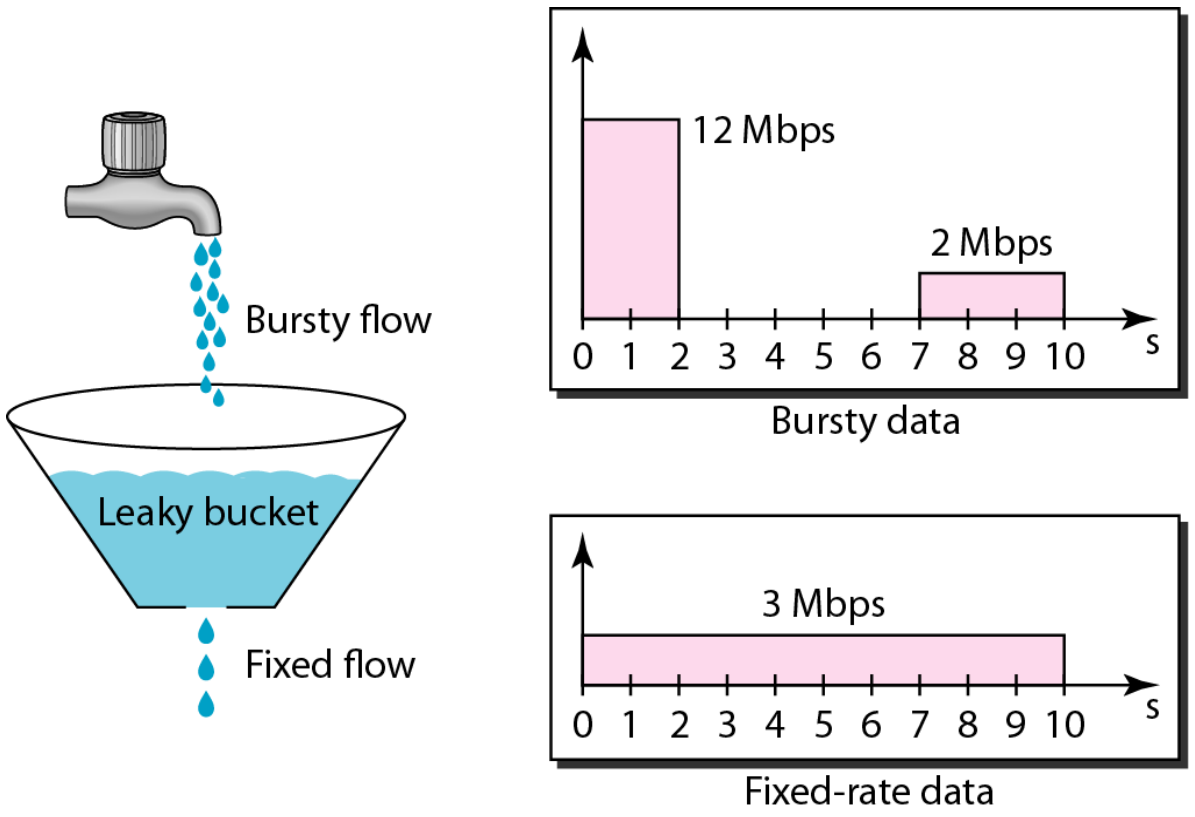
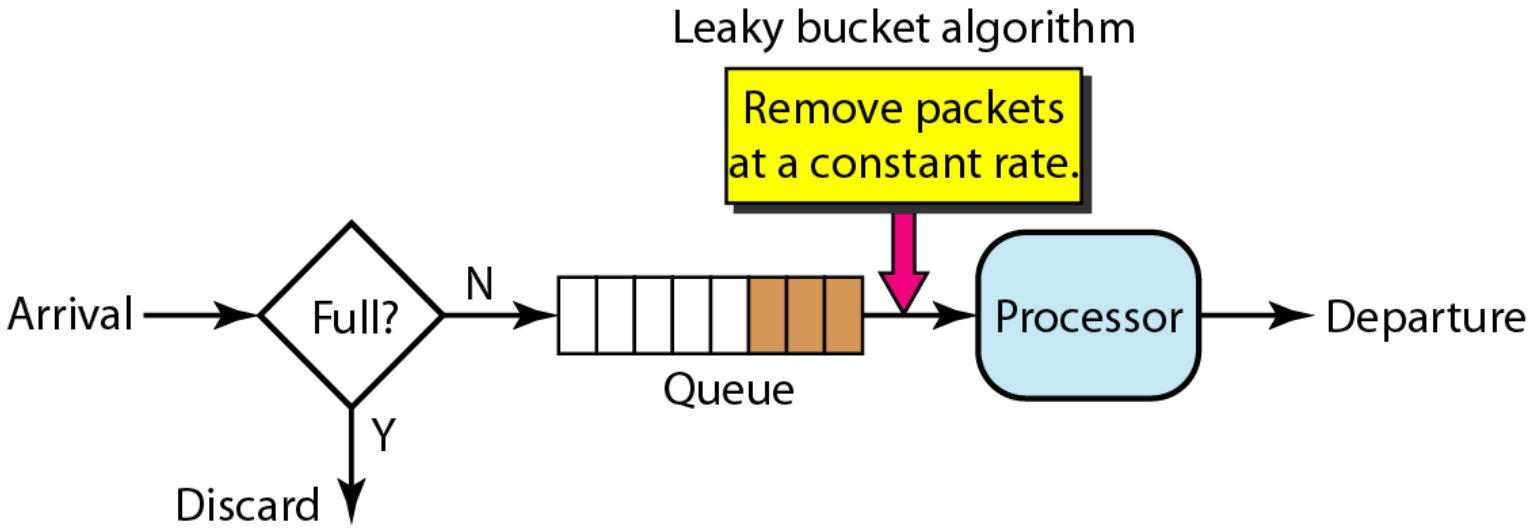
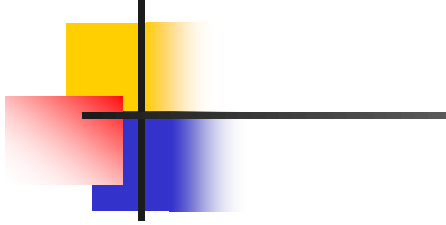
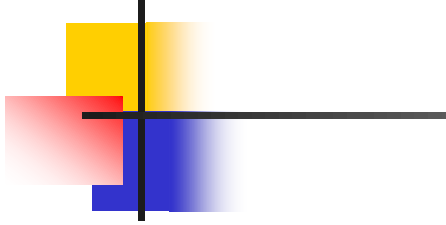


Figure *Leaky bucket implementation*



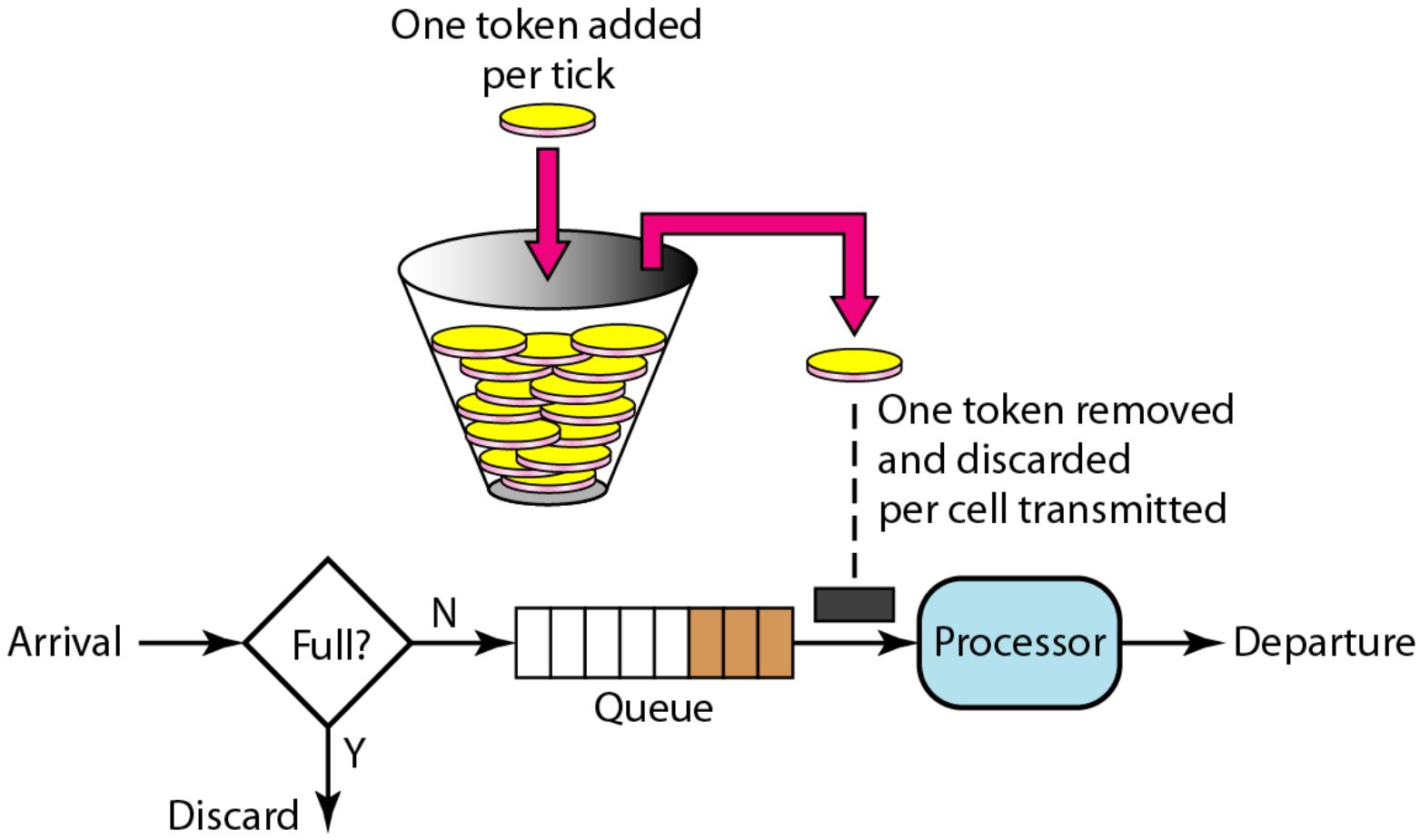


A leaky bucket algorithm shapes bursty traffic into fixed-rate traffic by averaging the data rate. It may drop the packets if the bucket is full.



The token bucket allows bursty traffic at a regulated maximum rate.

Figure *Token bucket*



24-7 INTEGRATED SERVICES

Two models have been designed to provide quality of service in the Internet: Integrated Services and Differentiated Services. We discuss the first model here.

Topics discussed in this section:

Signaling
Flow Specification
Admission
Service Classes
RSVP
Problems with Integrated Services

Note

Integrated Services is a flow-based QoS model designed for IP.

Figure 24.22 *Path messages*

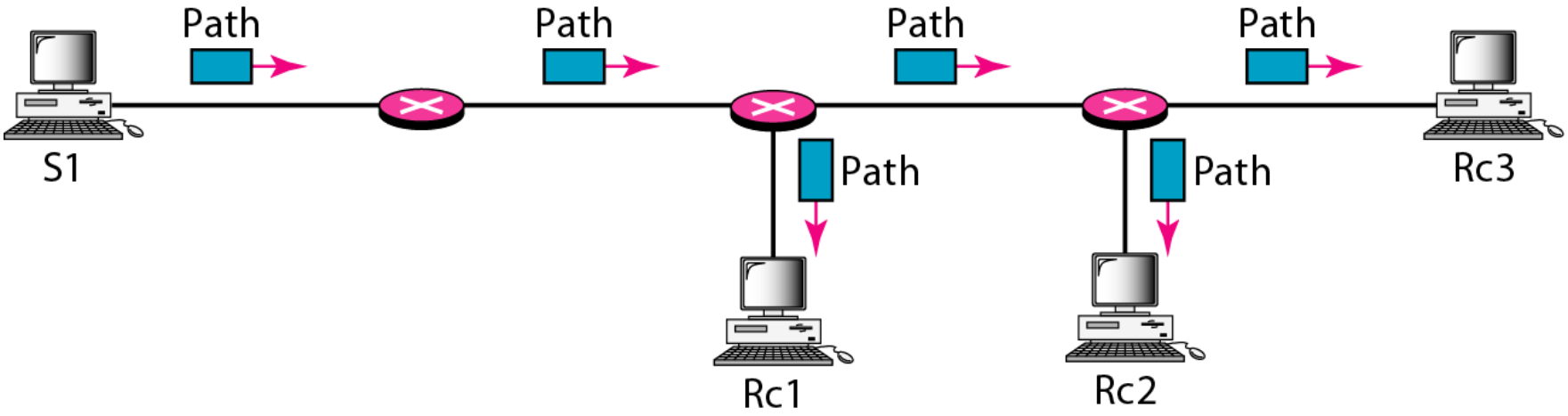


Figure 24.23 *Resv messages*

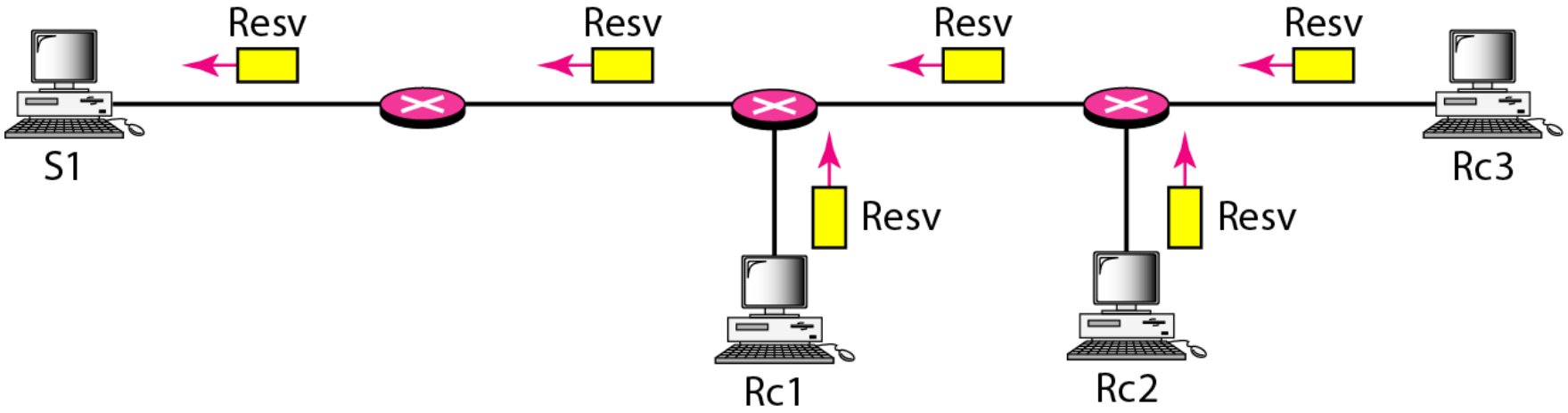


Figure 24.24 *Reservation merging*

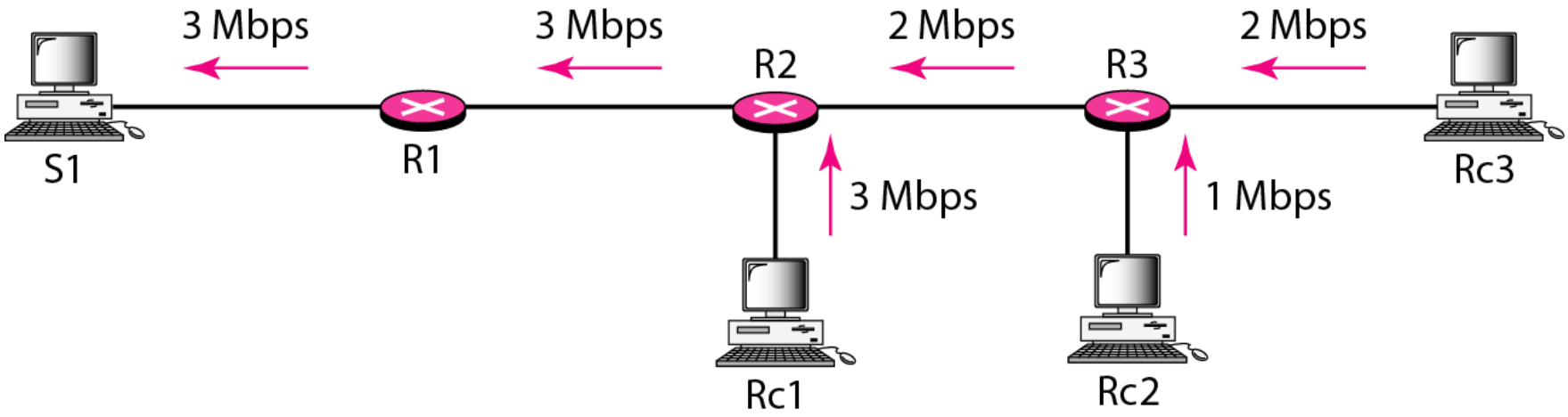
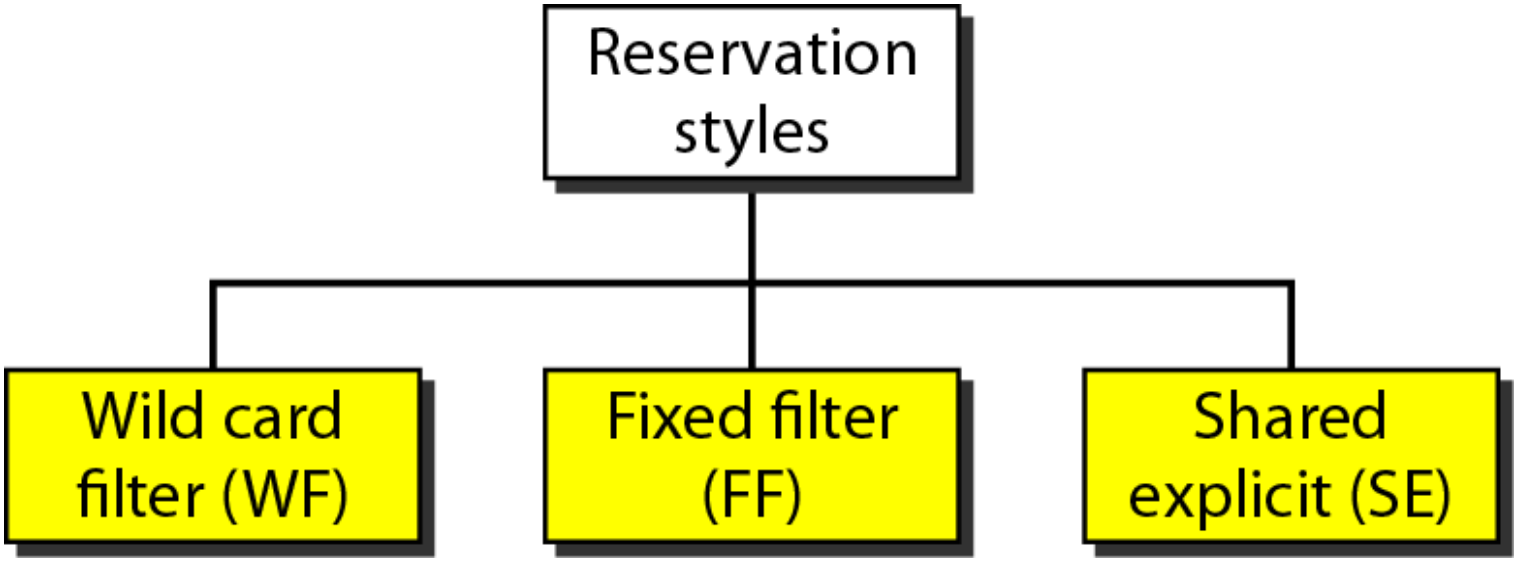


Figure 24.25 ***Reservation styles***



24-8 DIFFERENTIATED SERVICES

Differentiated Services (DS or Diffserv) was introduced by the IETF (Internet Engineering Task Force) to handle the shortcomings of Integrated Services.

Topics discussed in this section:

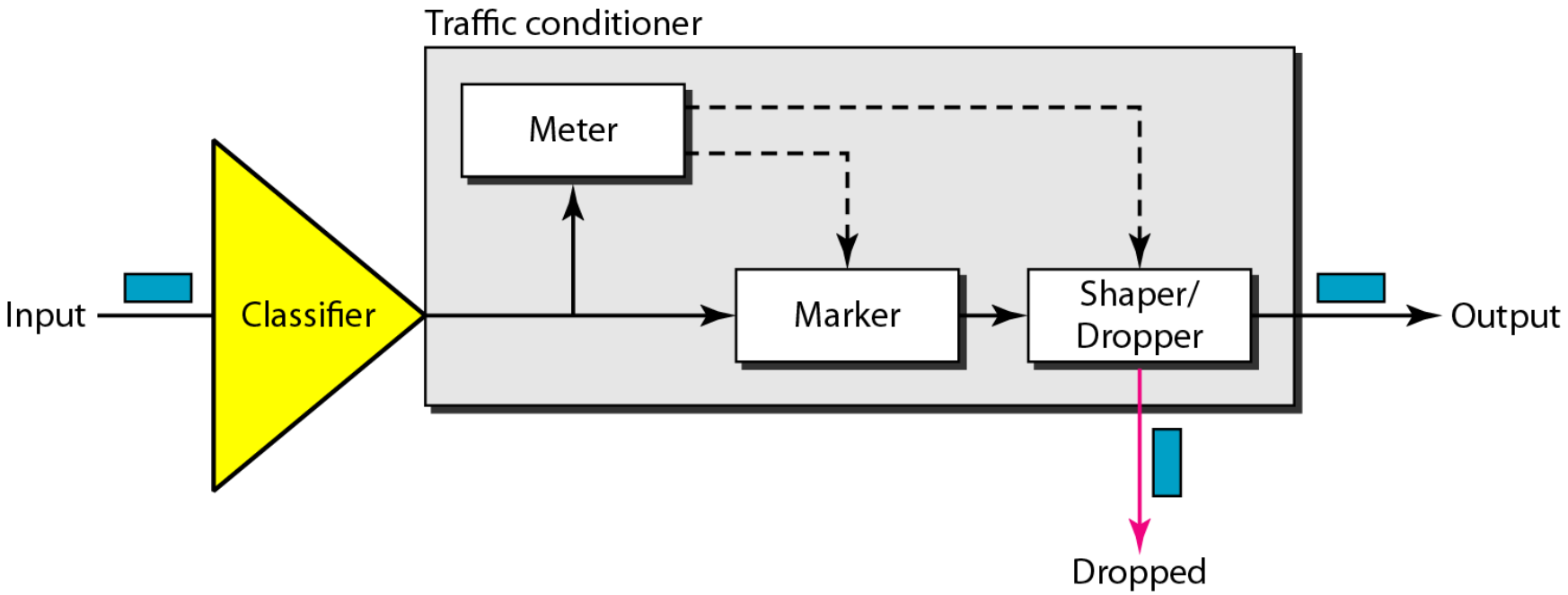
DS Field

Note

Differentiated Services is a class-based QoS model designed for IP.

Figure 24.26 *DS field*

Figure 24.27 *Traffic conditioner*



24-9 QoS IN SWITCHED NETWORKS

Let us now discuss QoS as used in two switched networks: Frame Relay and ATM. These two networks are virtual-circuit networks that need a signaling protocol such as RSVP.

Topics discussed in this section:

QoS in Frame Relay
QoS in ATM

Figure 24.28 *Relationship between traffic control attributes*

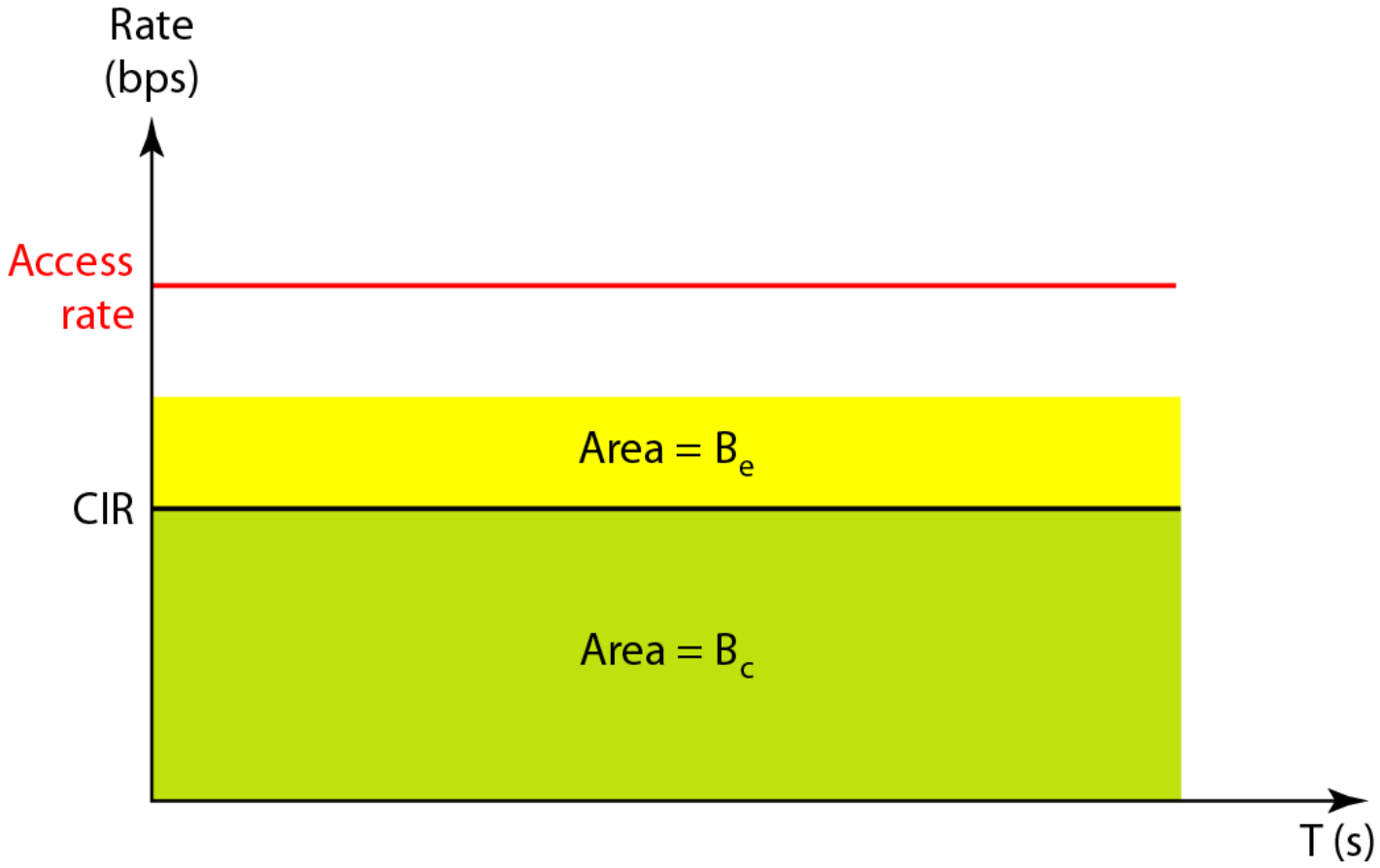


Figure 24.29 *User rate in relation to Bc and Bc + Be*

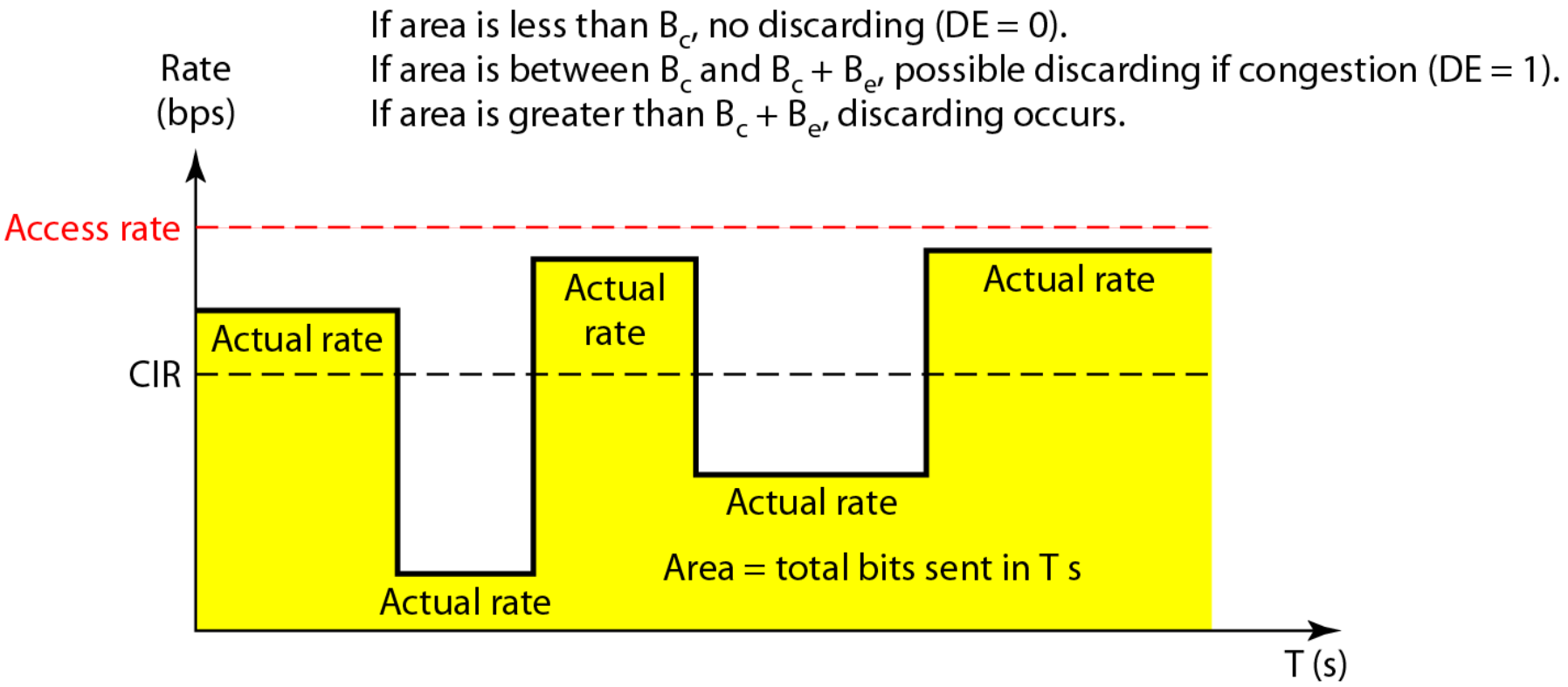


Figure 24.30 *Service classes*

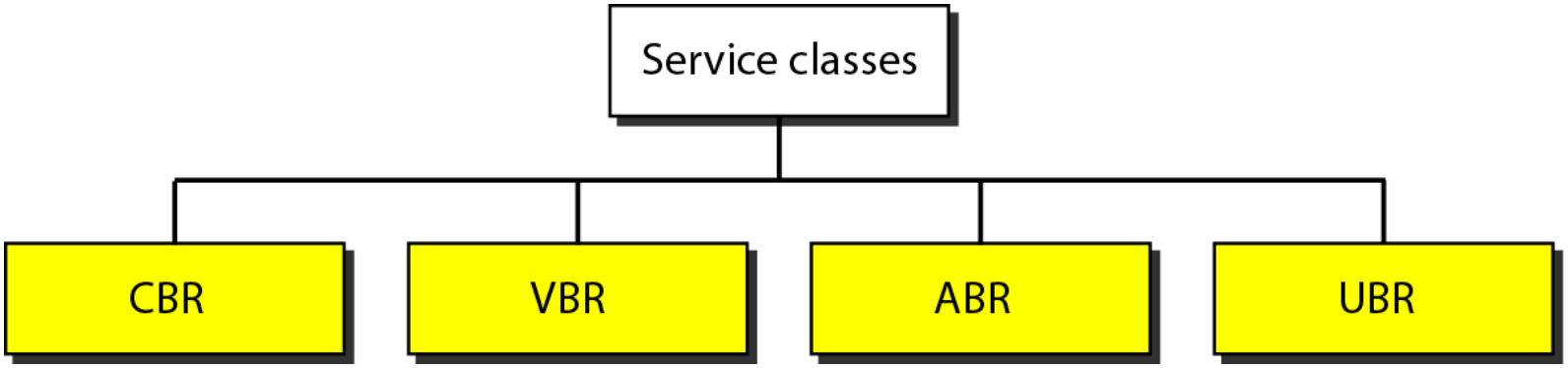


Figure 24.31 *Relationship of service classes to the total capacity of the network*