Unit-5
Congestion Control and QoS

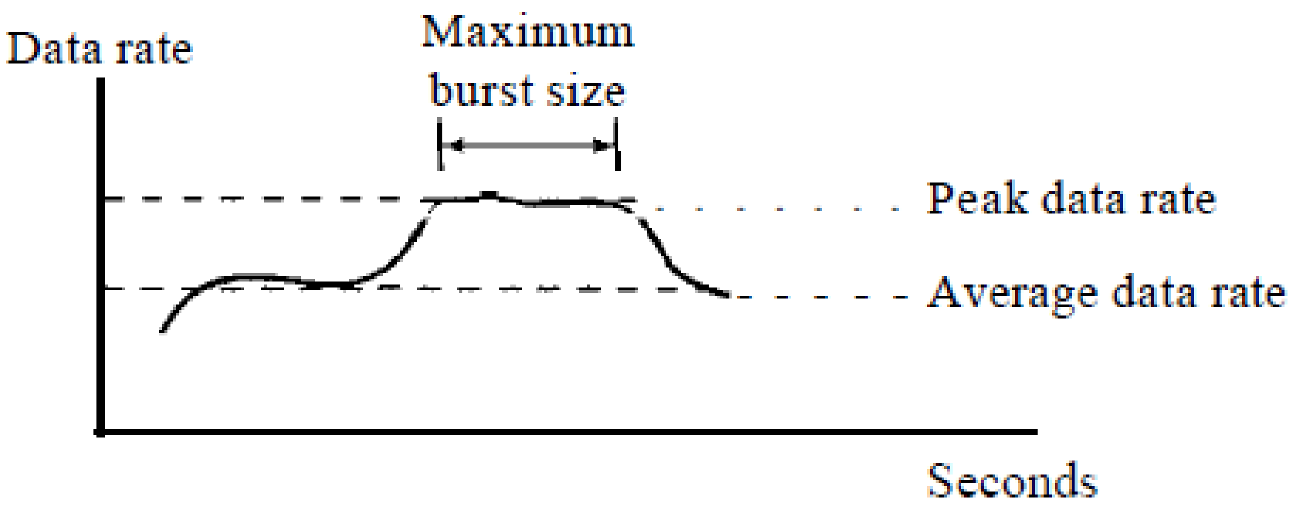
Dr. Manmohan Sharma
Professor
School of Computer Applications
Lovely Professional University

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.

Traffic Descriptor

- Traffic descriptors are qualitative values that represent a data flow.



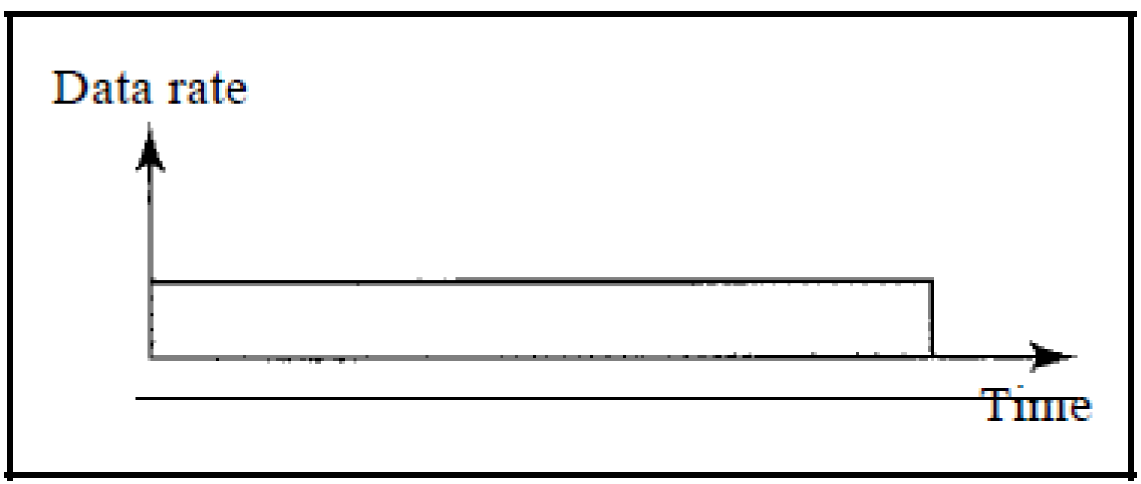
- ***Average Data Rate:*** The average data rate is the number of bits sent during a period of time, divided by the number of seconds in that period. We use the following equation:

$$\text{Average data rate} = \frac{\text{amount of data}}{\text{time}}$$

- ***Peak Data Rate:*** The peak data rate defines the maximum data rate of the traffic. In Figure 24.1 it is the maximum *y axis value. The peak data rate is a very important measurement because* it indicates the peak bandwidth that the network needs for traffic to pass through without changing its data flow.
- ***Maximum Burst Size:*** Although the peak data rate is a critical value for the network, it can usually be ignored if the duration of the peak value is very short. The maximum burst size normally refers to the maximum length of time the traffic is generated at the peak rate.
- ***Effective Bandwidth:*** The effective bandwidth is the bandwidth that the network needs to allocate for the flow of traffic. The effective bandwidth is a function of three values: average data rate, peak data rate, and maximum burst size. The calculation of this value is very complex.

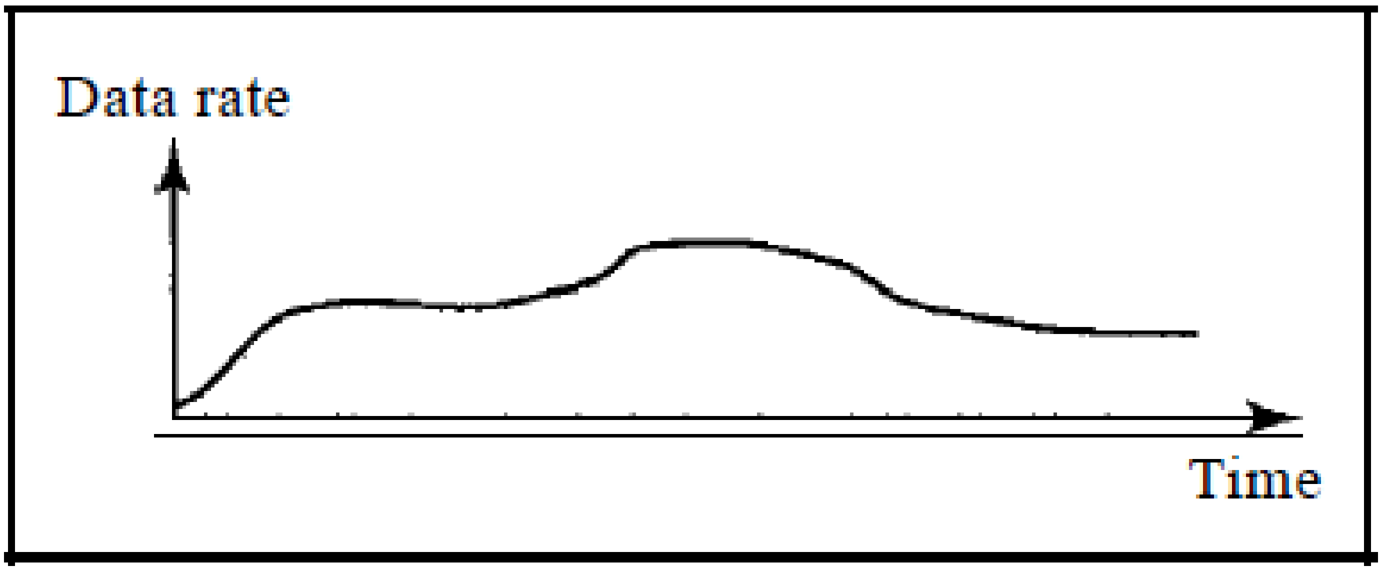
Traffic Profiles

- ***Constant Bit Rate:*** A constant-bit-rate (CBR), or a fixed-rate, traffic model has a data rate that does not change. In this type of flow, the average data rate and the peak data rate are the same. The maximum burst size is not applicable. This type of traffic is very easy for a network to handle since it is predictable. The network knows in advance how much bandwidth to allocate for this type of flow.



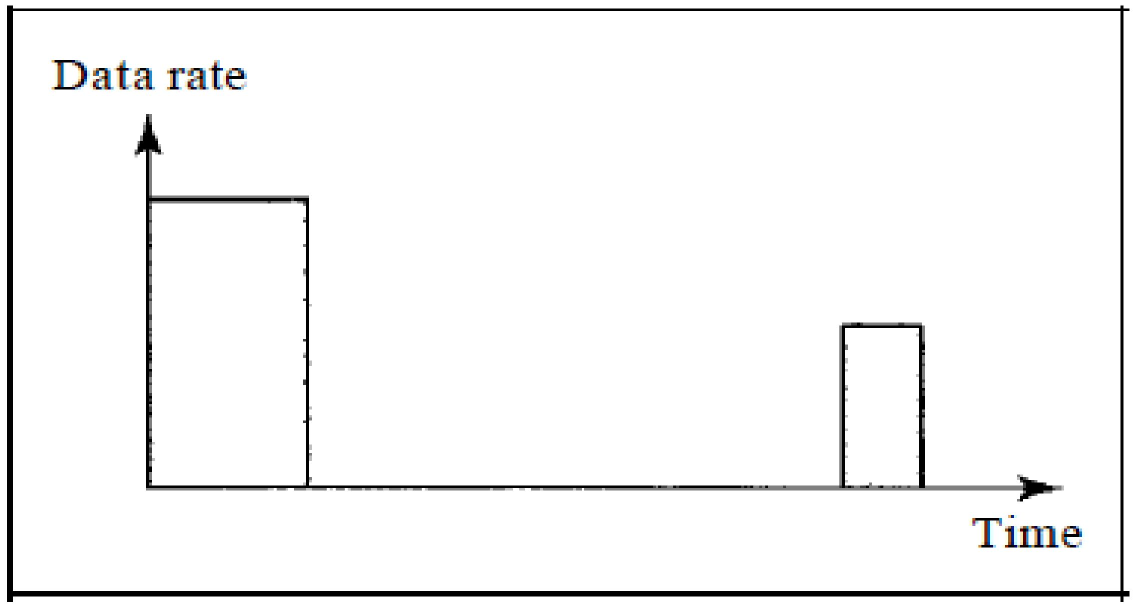
a. Constant bit rate

- ***Variable Bit Rate:*** In the variable-bit-rate (VBR) category, the rate of the data flow changes in time, with the changes smooth instead of sudden and sharp. In this type of flow, the average data rate and the peak data rate are different. The maximum burst size is usually a small value.



b. Variable bit rate

- ***Bursty Data Rate:*** In this category the data rate changes suddenly in a very short time. It may jump from zero, for example, to 1 Mbps in a few microseconds and vice versa. It may also remain at this value for a while. The average bit rate and the peak bit rate are very different values in this type of flow.



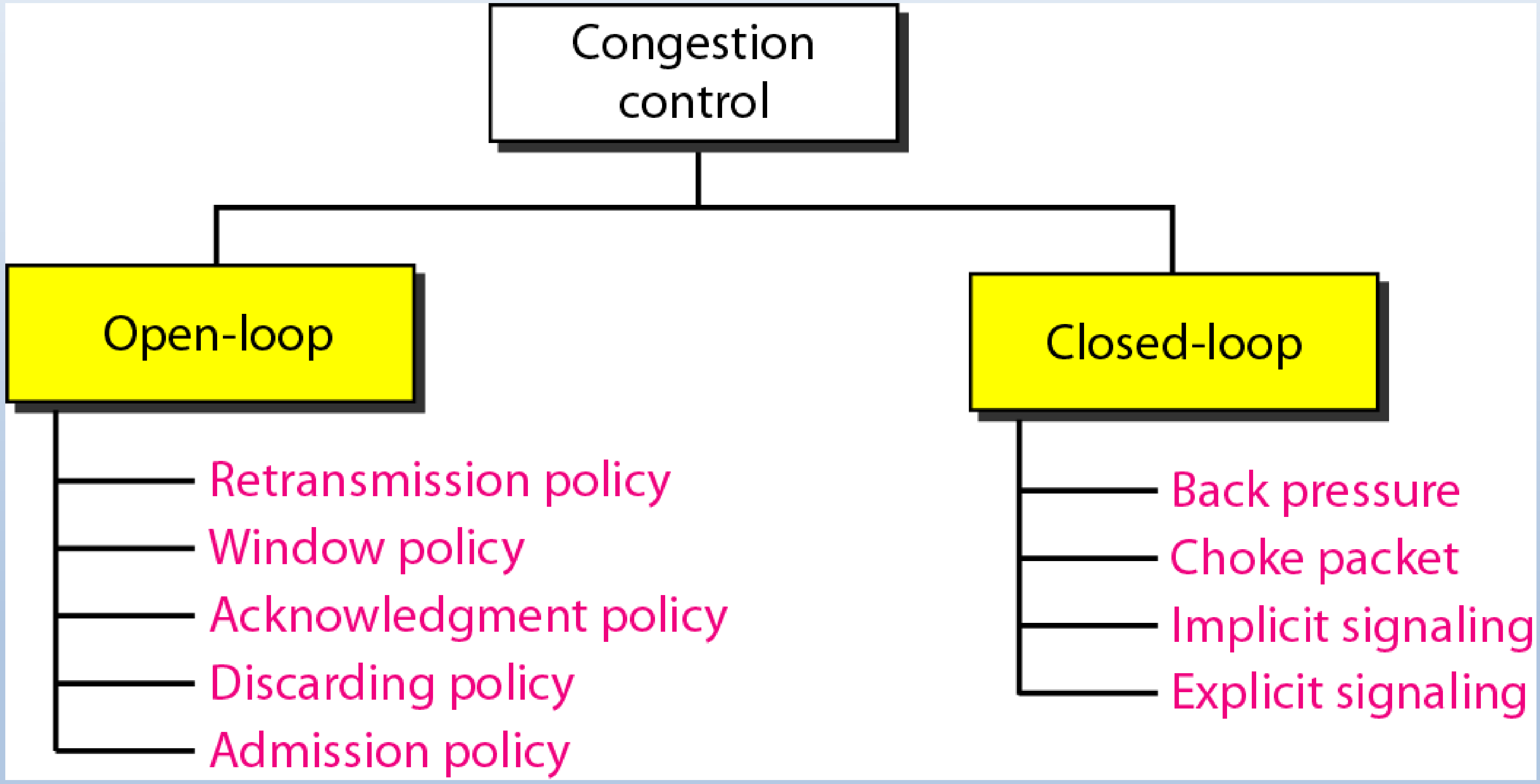
c. Bursty

Congestion Control

- An important issue in a packet-switched network is **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.

- 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)
  - Closed-loop congestion control (removal).

Congestion Control Categories



Open Loop Congestion Control

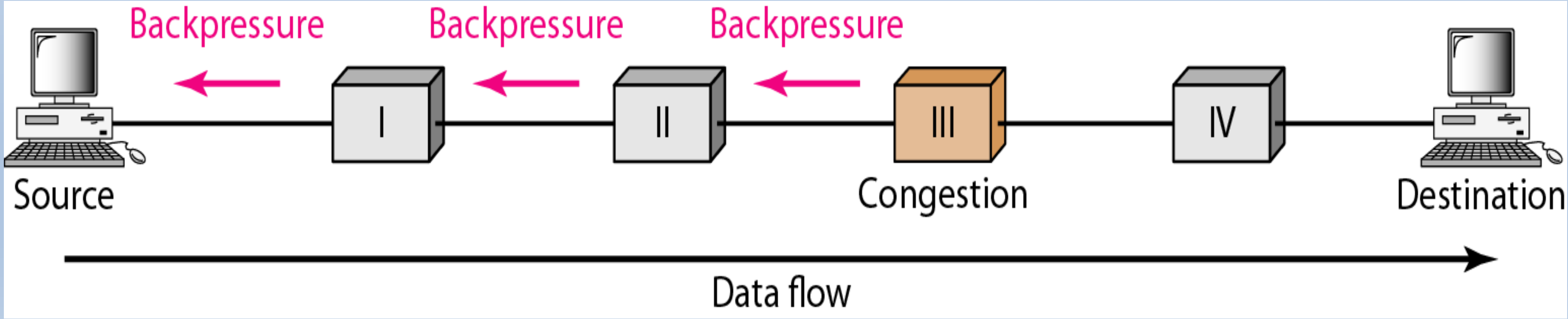
- **Retransmission Policy:**
  - If the sender feels that a sent packet is lost or corrupted, the packet needs to be retransmitted.
  - The retransmission policy and the retransmission timers must be designed to optimize efficiency and at the same time prevent congestion.
- **Window Policy:**
  - The type of window at the sender may also affect congestion.
  - The Selective Repeat window is better than the Go-Back-N window for congestion control.
  - In the *Go-Back-N* window, when the timer for a packet times out, several packets may be resent, although some may have arrived safe and sound at the receiver.

- **Acknowledgement Policy:**
  - If the receiver does not acknowledge every packet it receives, it helps prevent congestion.
- **Discarding Policy:**
  - In this policy less sensitive packets may be discarded when congestion is likely to happen
- **Admission Policy:**
  - A router can deny establishing a virtual circuit connection if there is congestion in the network or if there is a possibility of future congestion.

Closed Loop Congestion Control

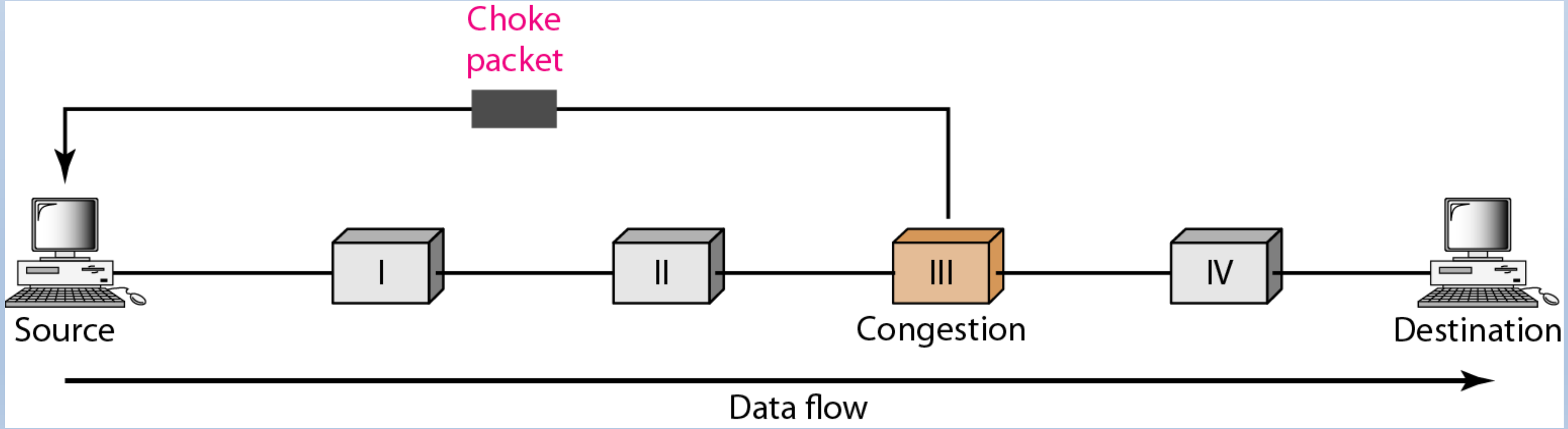
Backpressure

- It is a node-to-node congestion control that starts with a node and propagates, in the opposite direction of data flow, to the source.
- The backpressure technique can be applied only to virtual circuit networks, in which each node knows the upstream node from which a flow of data is coming.



Choke Packet:

- A choke packet is a packet sent by a node to the source to inform it about congestion.
- The warning is from the router, which has encountered congestion, to the source station directly.



Implicit Signalling:

- there is no communication between the congested node or nodes and the source.
- The source guesses that there is a congestion somewhere in the network from other symptoms.

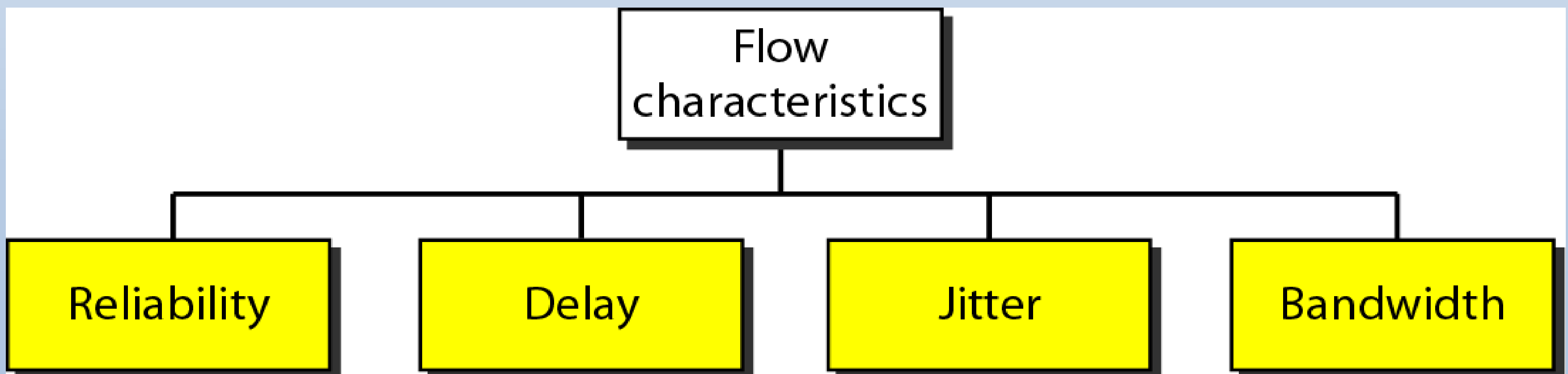
Explicit Signaling:

- The node that experiences congestion can explicitly send a signal to the source or destination.
  - **Backward Signaling** A bit can be set in a packet moving in the direction opposite to the congestion. This bit can warn the source that there is congestion and that it needs to slow down to avoid the discarding of packets.
  - **Forward Signaling** A bit can be set in a packet moving in the direction of the congestion. This bit can warn the destination that there is congestion.

Quality of Service (QoS)

Quality of Service can be defined as something a flow seeks to attain.

Flow Characteristics:

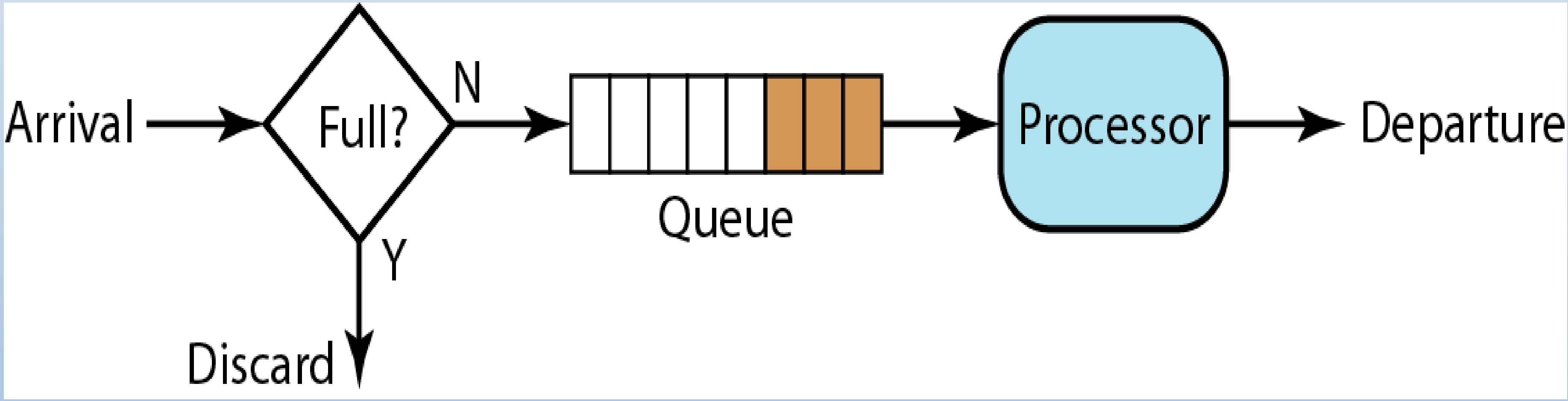


Techniques to Improve QoS

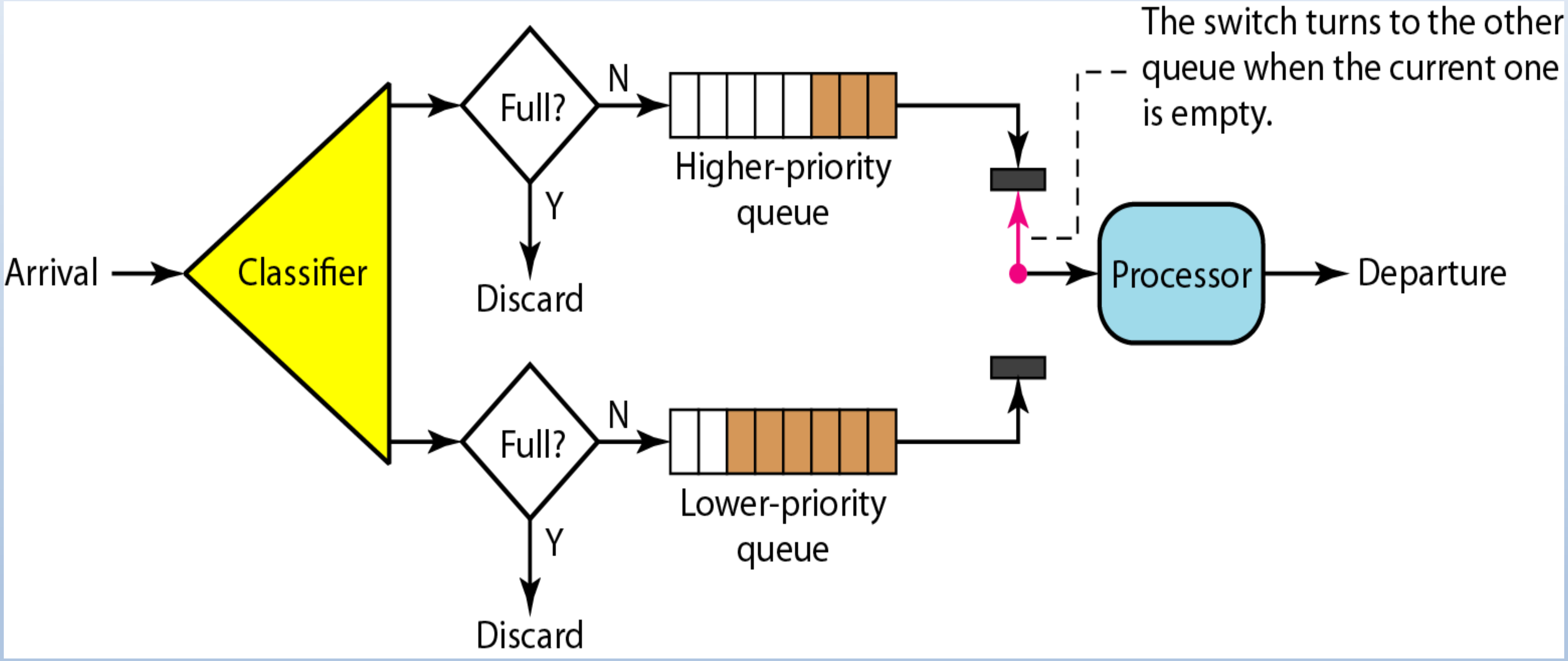
- **Scheduling**
- **Traffic Shaping**
- **Resource Reservation**
- **Admission Control**

Scheduling

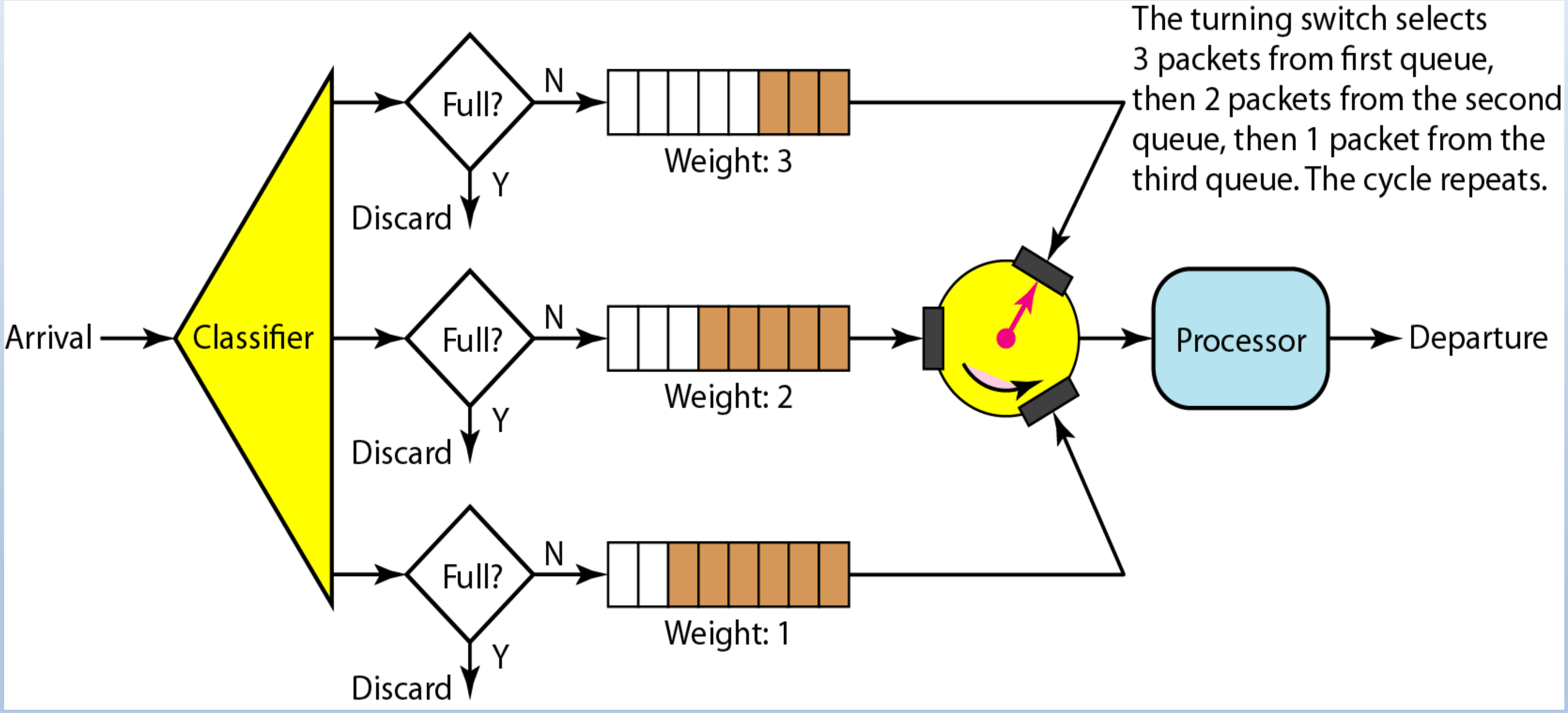
FIFO Queuing



Priority Queuing

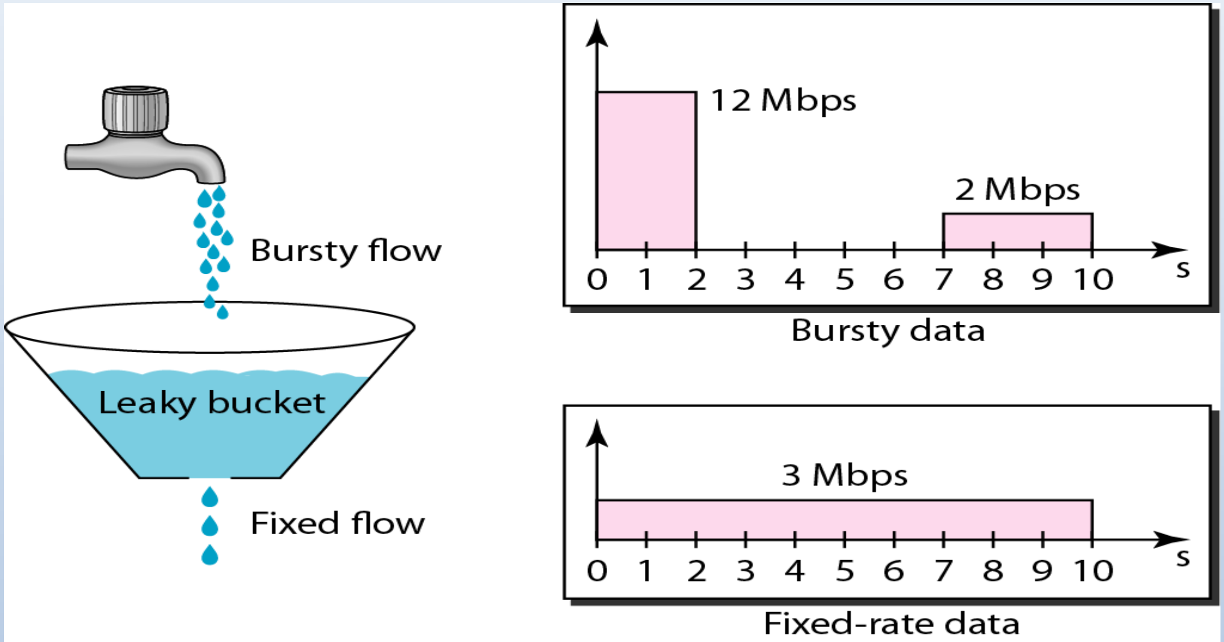


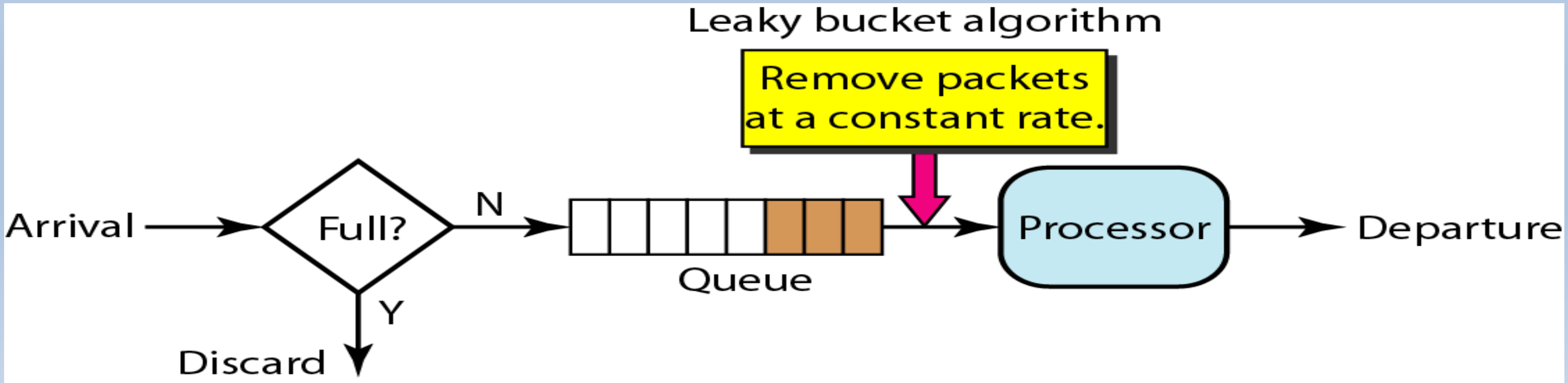
Weighted Fair Queuing



Traffic Shaping

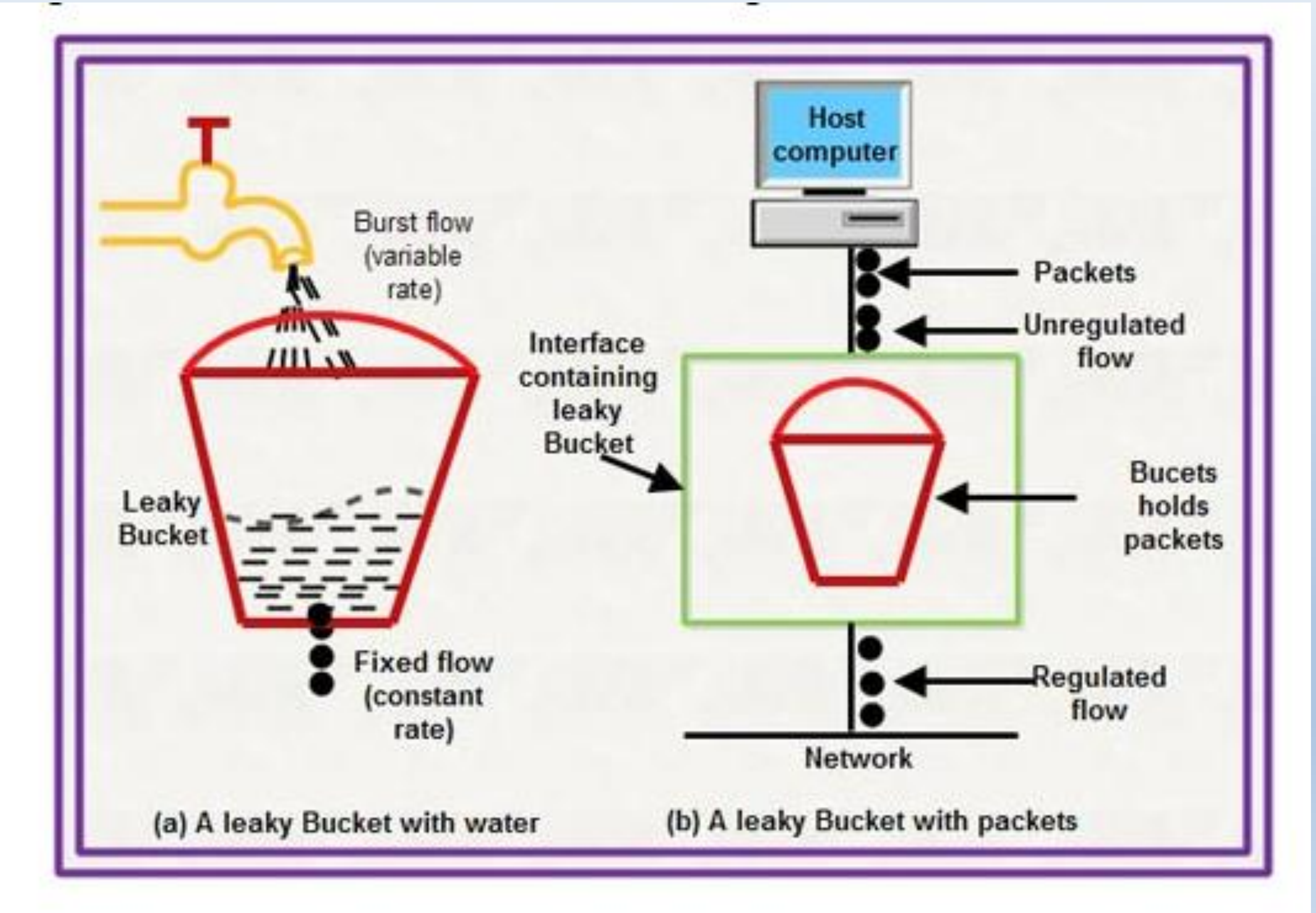
Leaky Bucket





Traffic Shaping

Leaky Bucket

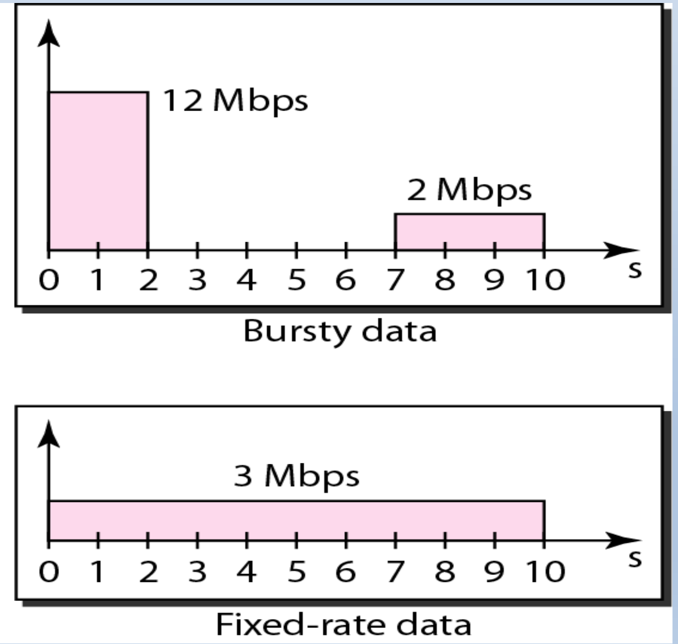


(a) A leaky Bucket with water (b) A leaky Bucket with packets

Traffic Shaping

In the figure, we assume that the network has committed a bandwidth of 3 Mbps for a host.

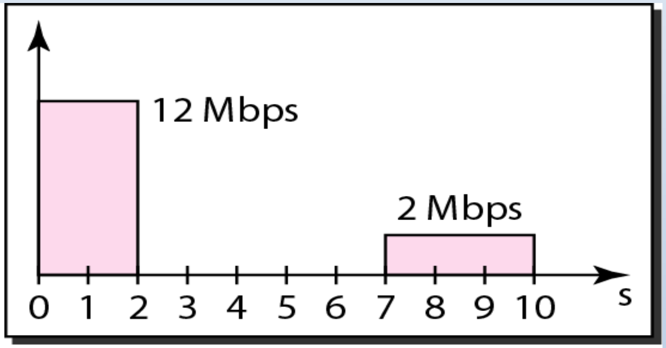
The use of the leaky bucket shapes the input traffic to make it conform to this commitment.



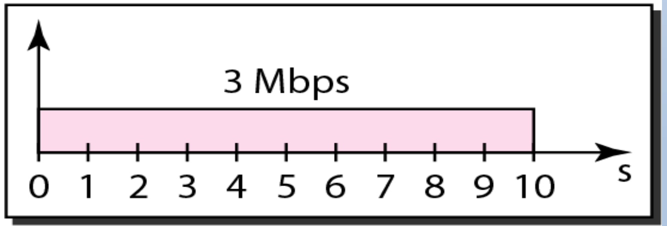
Traffic Shaping

In Figure the host sends a burst of data at a rate of 12 Mbps for 2s, for a total of 24 Mbits of data.

The host is silent for 5s and then sends data at a rate of 2Mbps for 3s, for a total of 6Mbits of data.



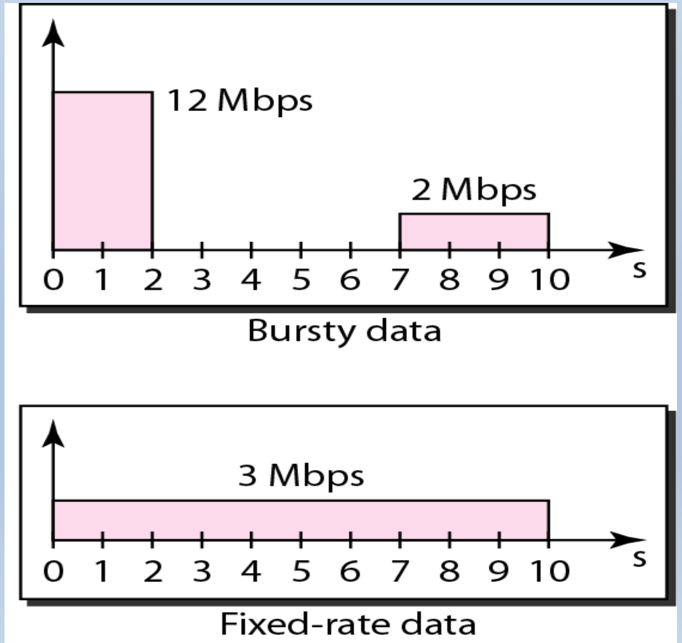
Bursty data



Fixed-rate data

Traffic Shaping

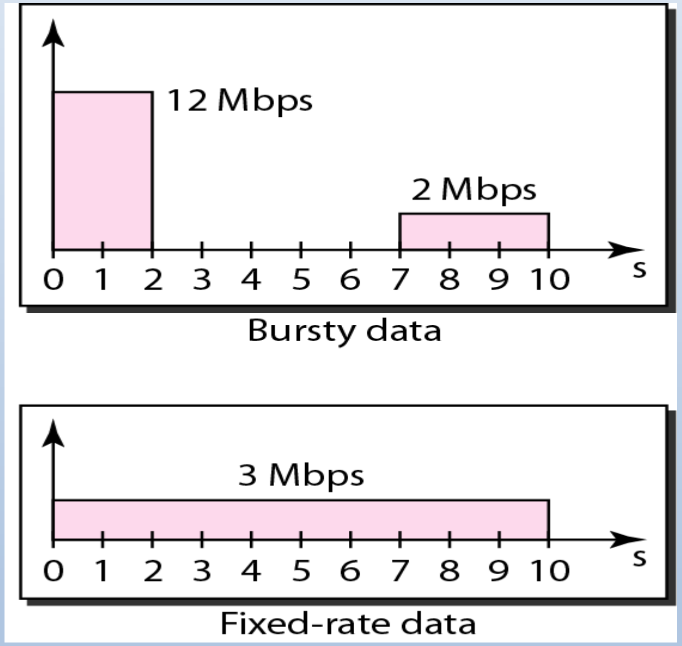
In all, the host has sent
30 Mbits of data in lOs.



Traffic Shaping

The leaky bucket smooth's the traffic by sending out data at a rate of 3Mbps during the same 10s.

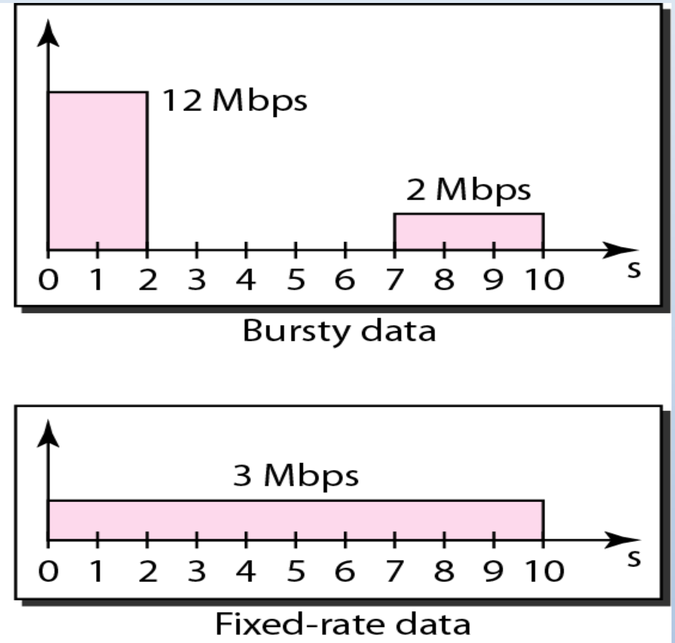
Without the leaky bucket, the beginning burst may have hurt the network by consuming more bandwidth than is set aside for this host.



Traffic Shaping

We can also see that the leaky bucket may prevent congestion.

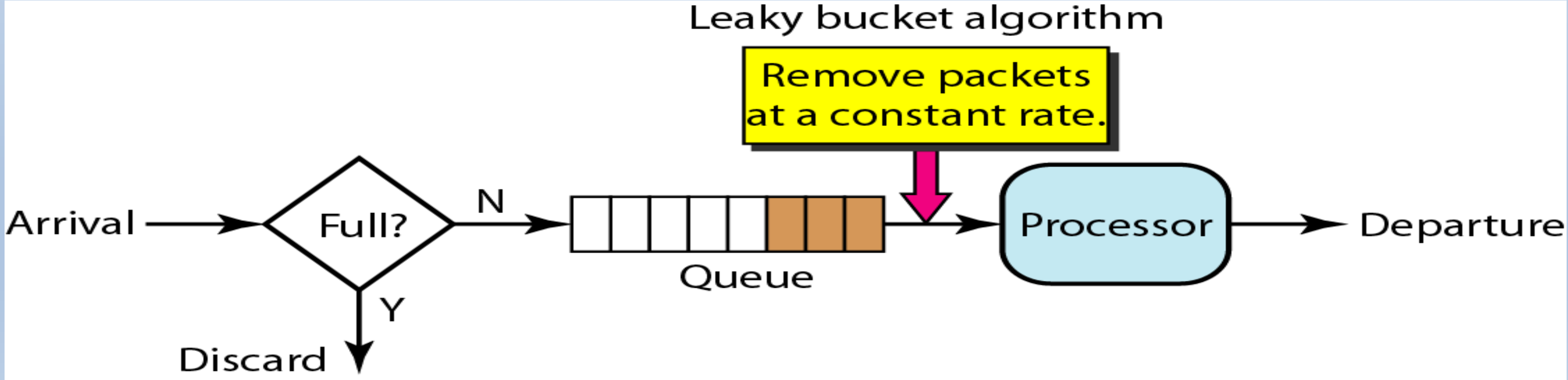
As an analogy, consider the freeway during rush hour (bursty traffic). If, instead, commuters could stagger their working hours, congestion on our freeways could be avoided.



Traffic Shaping

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.

Implementation of Leaky Bucket Algorithm



Token Bucket

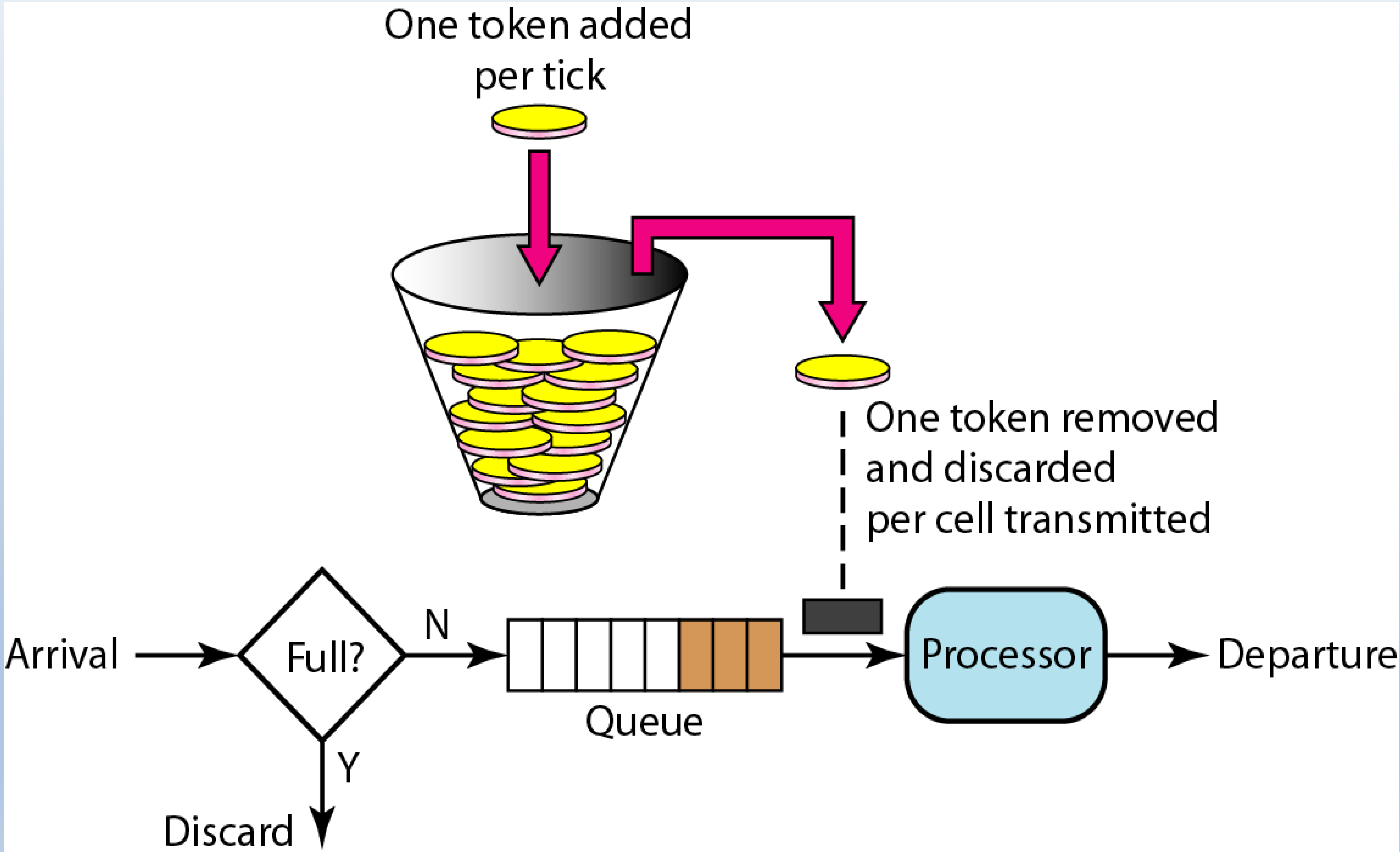
The leaky bucket is very restrictive. It does not credit an idle host.

For example, if a host is not sending for a while, its bucket becomes empty.

Now if the host has bursty data, the leaky bucket allows only an average rate.

The time when the host was idle is not taken into account.

Token Bucket



Token Bucket

The token bucket algorithm allows idle hosts to accumulate credit for the future in the form of tokens.

For each tick of the clock, the system sends *n* tokens to the bucket.

Token Bucket

The system removes one token for every cell (or byte) of data sent.

For example, if *n* is 100 and the host is idle for 100 ticks, the bucket collects 10,000 tokens. Now the host can consume all these tokens in one tick with 10,000 cells, or the host takes 1000 ticks with 10 cells per tick.

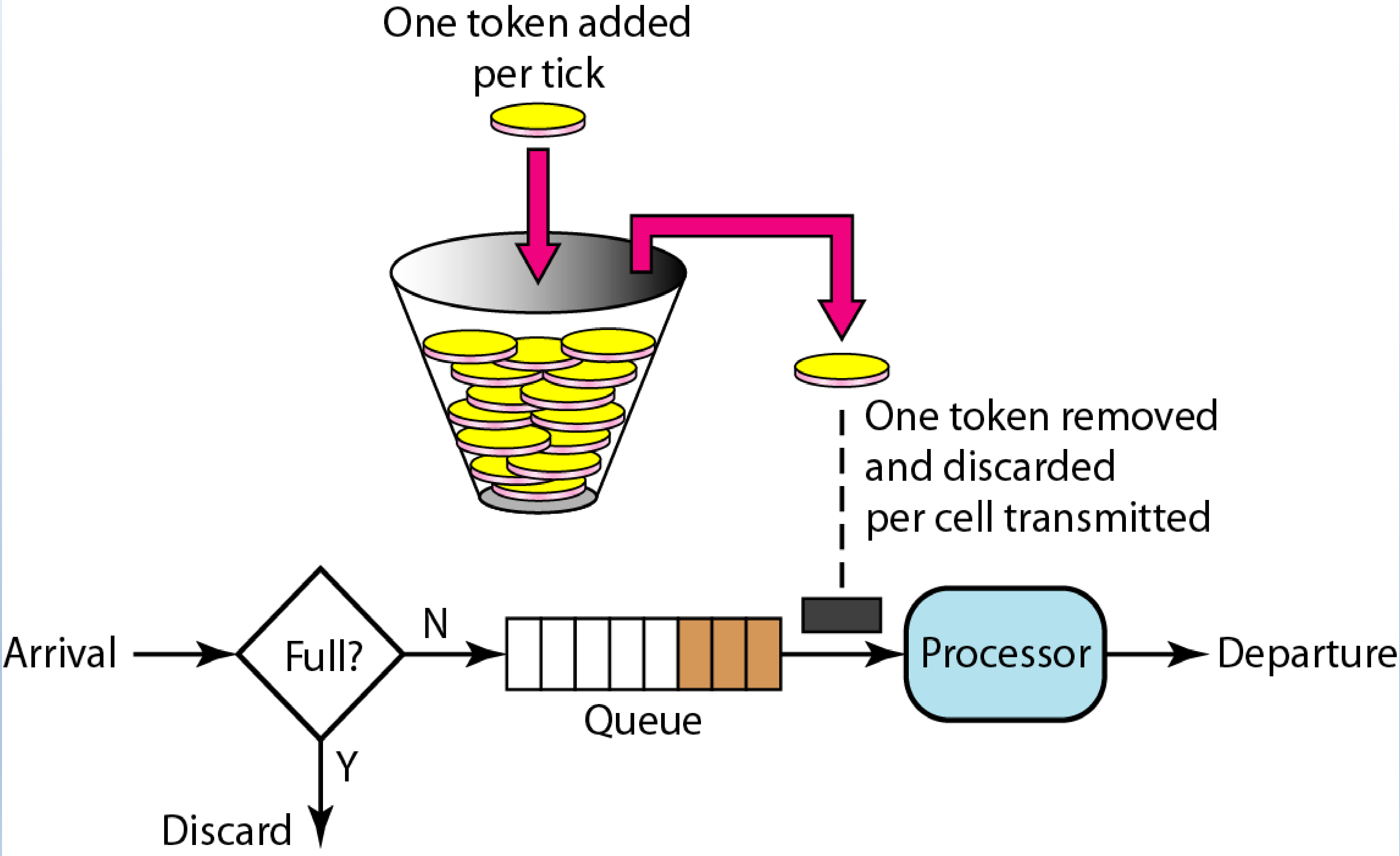
I

Token Bucket

In other words, the host can send bursty data as long as the bucket is not empty. Figure shows the idea. The token bucket can easily be implemented with a counter.

The token is initialized to zero. Each time a token is added, the counter is incremented by 1. Each time a unit of data is sent, the counter is decremented by 1. When the counter is zero, the host cannot send data.

Token Bucket



Resource Reservation:

- A flow of data needs resources such as a buffer, bandwidth, CPU time, and so on.
- The quality of service is improved if these resources are reserved beforehand.

Admission Control:

- Admission control refers to the mechanism used by a router, or a switch, to accept or reject a flow based on predefined parameters called flow specifications.