Computer Networks: Congestion Control and QoS

By,

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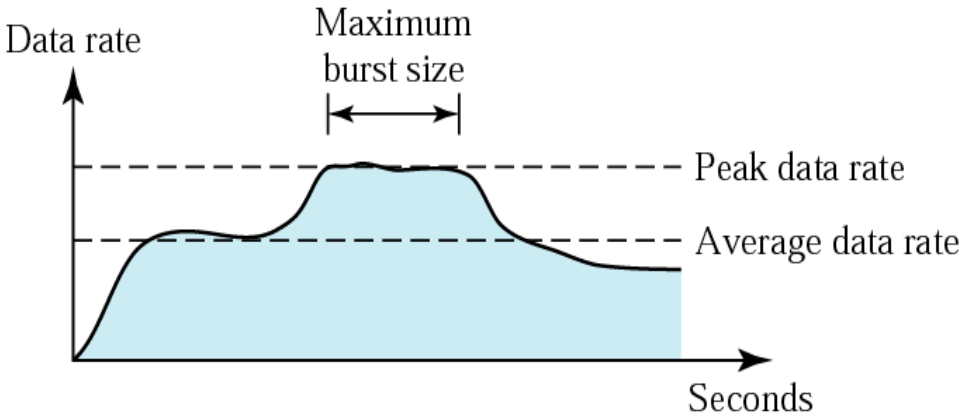
Network Congestion: What It is ??

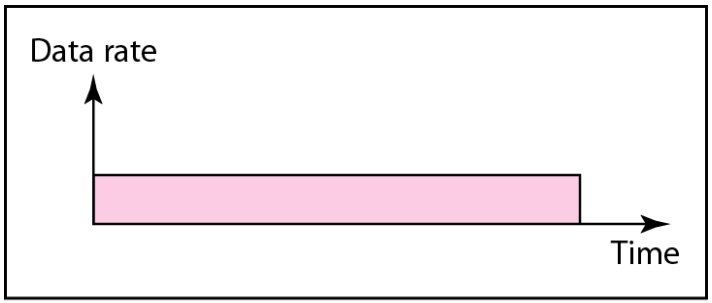
- *Network Congestion* is the situation in which an increase in data transmissions results in reduction of *Throughput*.
- Congestion occurs when the number of packets being transmitted through the network approaches the packet handling capacity of the network.
- Congestion Control Types.
  - ✓ Open Loop (Prevent Congestion occurring by Good Design)
  - ✓ Closed Loop (Detect => Feedback => Correct)
- Why Congestion Occurs ??
  - ✓ Bursty Traffic
  - ✓ Insufficient Memory
  - ✓ Low Buffer Space
  - ✓ Low Processor

Traffic Descriptors: What It is ??

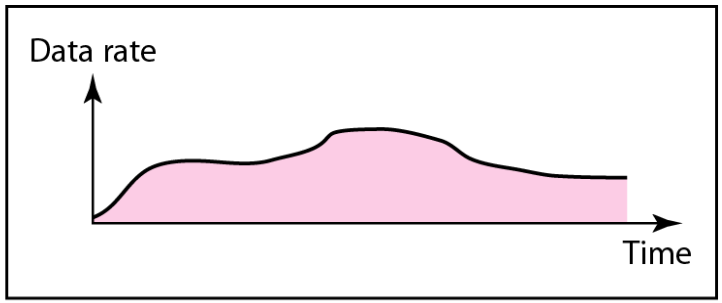
- **Average Data Rate**: Number of bits sent during a period of time, divided by the number of seconds in that period. Indicates the average bandwidth needed by the traffic.
- **Peak Data Rate**: Maximum data rate of the traffic. It indicates the peak bandwidth that the network needs for traffic to pass through the network without changing its data flow.
- **Maximum Burst Size**: Peak data rate is ignored if the duration of the peak value is very short. Maximum burst rate refers to the maximum length of time the traffic is generated at the peak rate.
- **Effective Bandwidth**: Bandwidth that the network needs to allocate for the flow of traffic. This depends on average data rate, peak data rate, and maximum burst size.



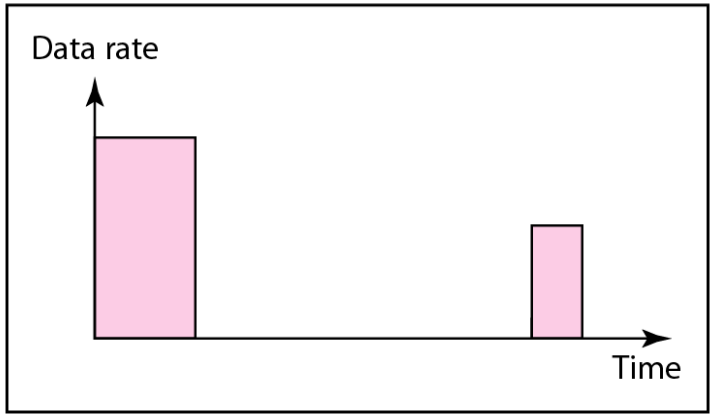
Traffic Profiles: Three Traffic Profiles



a. Constant bit rate



b. Variable bit rate

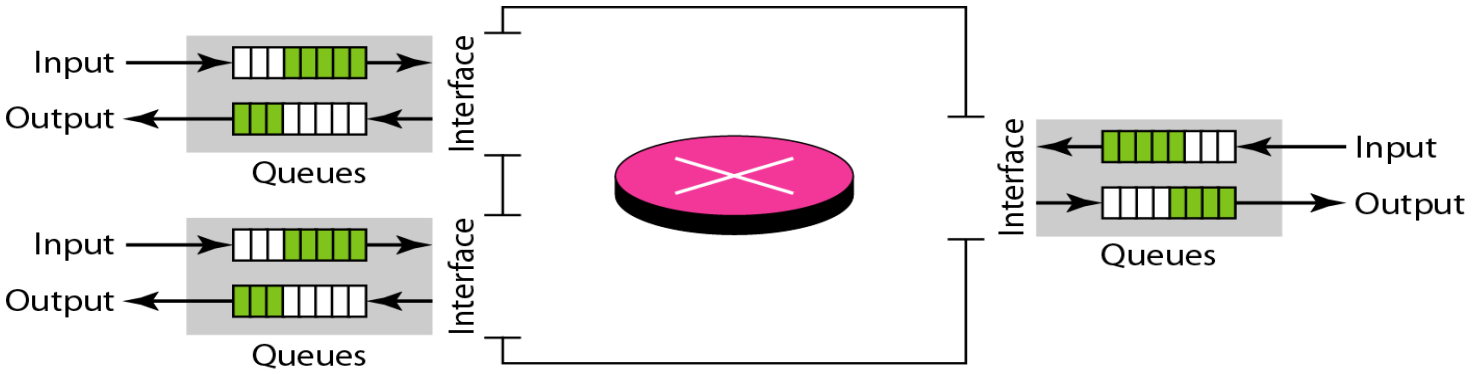


c. Bursty

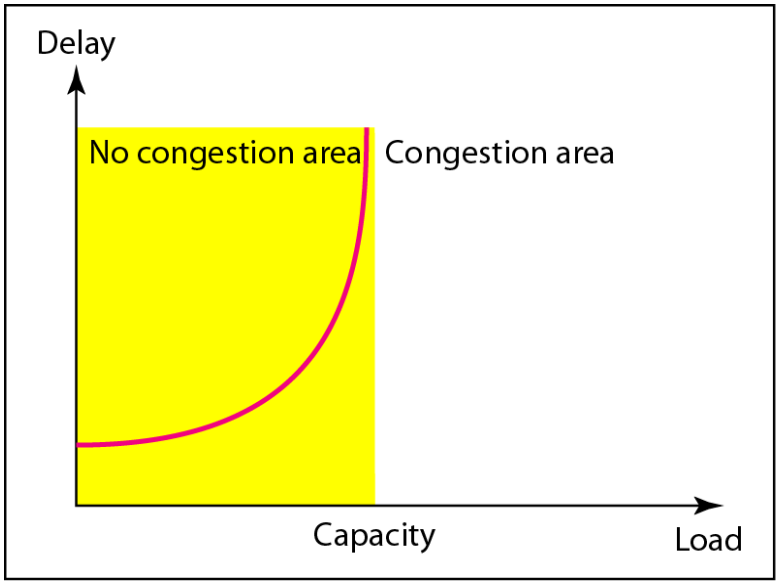
Queues in Router: What It is ??

When a packet arrives at incoming interface, it undergo three steps:

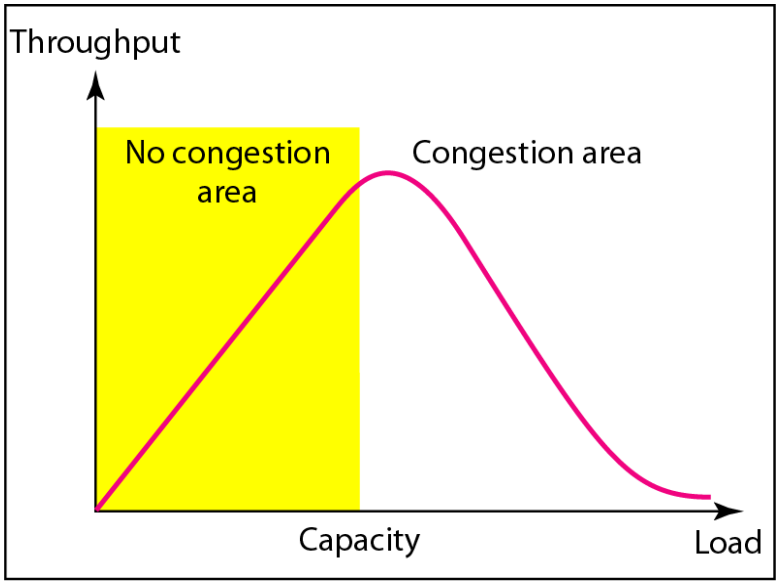
1. Packet is put at the end of input queue while waiting to be checked.
2. Processing module of the router removes the packet from front of queue and make routing decisions using routing table.
3. Packet is put into respective output queue and waits its turn to be sent.
   - ✓ **If rate of packet arrival > packet processing rate, Input queue size will increase.**
   - ✓ **If rate of processing > rate of departure, output queue increases**



Network Performance: Packet Delay and Throughput

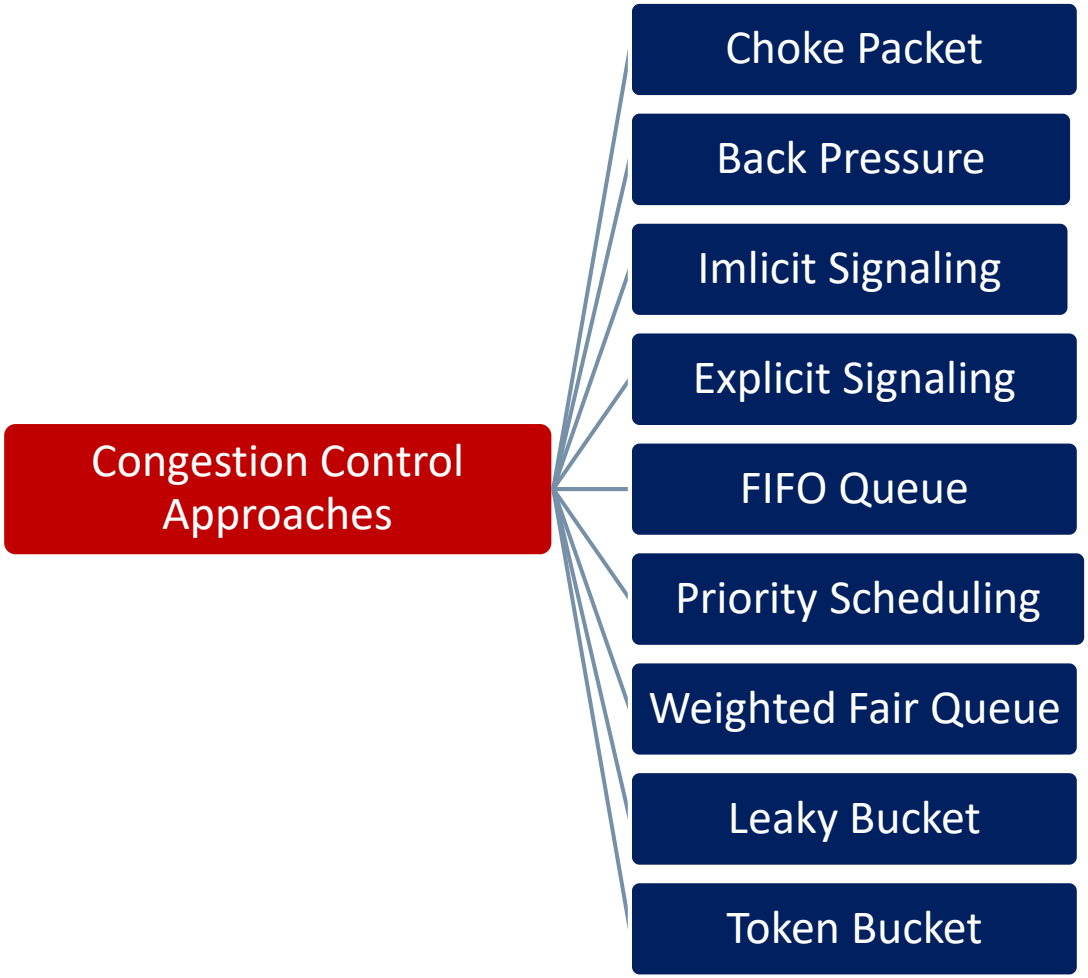


a. Delay as a function of load



b. Throughput as a function of load

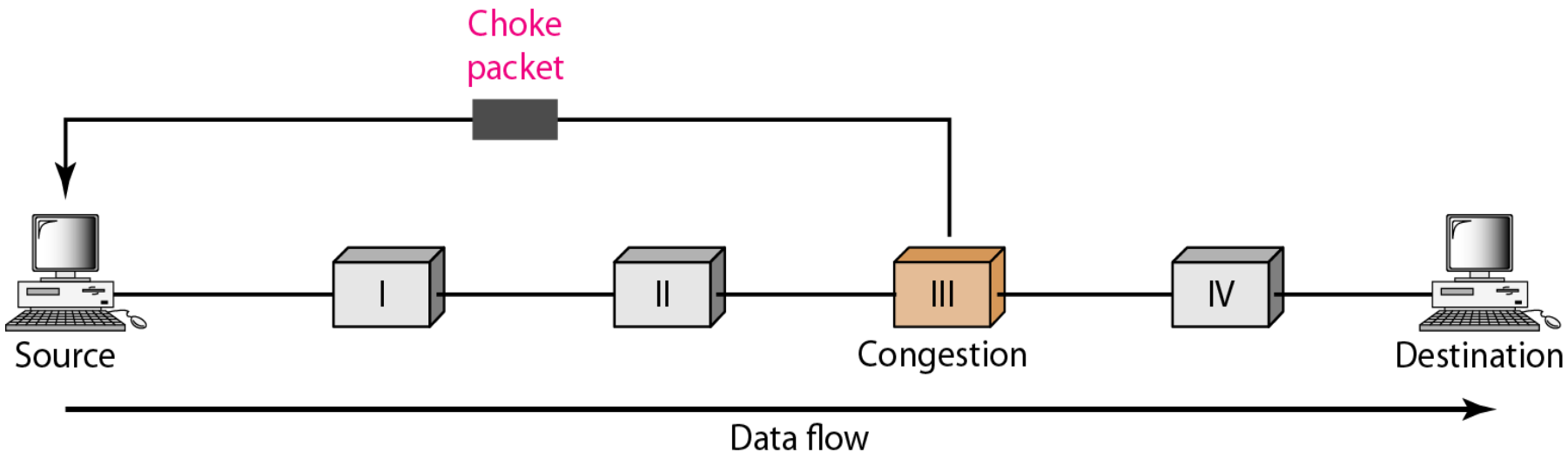
Congestion Control: Approaches ??



Congestion Control: Choke Packet

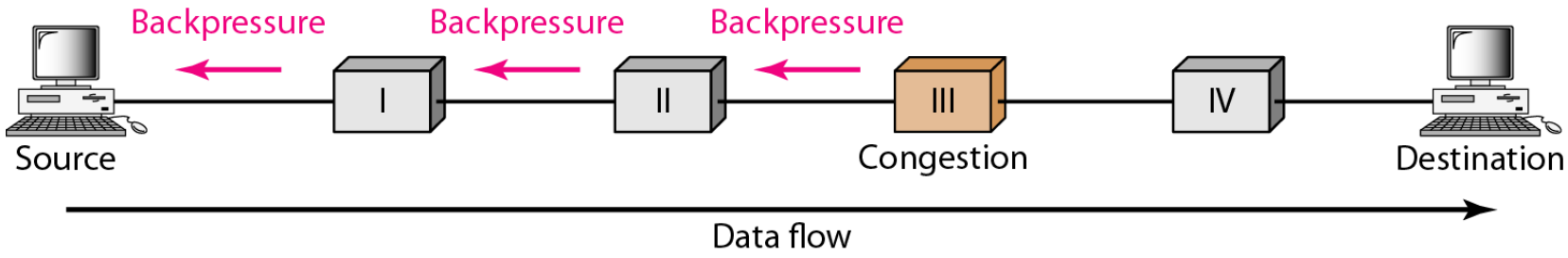
- A more direct way of telling the Source to Slow down.
- Choke Packet is a Control Packet generated at Congested Node.
- It is then transmitted to Source.
- The Source on receiving the Choke Packet must reduce its Transmission Rate.
- Hop by Hop Choke Packet is more efficient than Choke Packet.
- It Enables each Hop to reduce its Transmission Rate even before Choke Packet receives at Source.

Congestion Control: Choke Packet



Congestion Control: Back Pressure

- Informing the previous upstream router to reduce the rate of outgoing packets
- The action can be recursive all the way to the router before the source.



Congestion Control: Implicit and Explicit Signaling

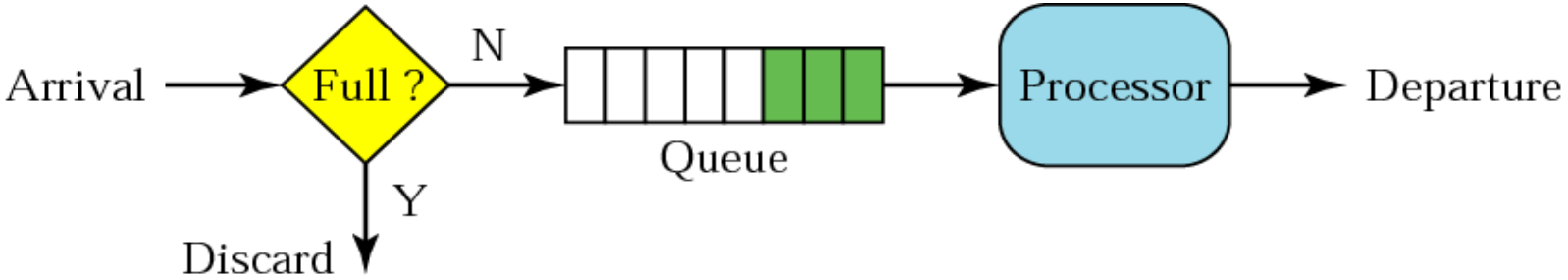
Implicit signaling

- ✓There is no communication between the congested node and the source.
- ✓The source guesses that there is a congestion somewhere in the network from other symptoms.
- ✓ For example, when a source sends several packets and there is no acknowledgment for a while, one assumption is that the network is congested.
- ✓The delay in receiving an acknowledgment is interpreted as congestion in the network
- ✓The source should slow down.

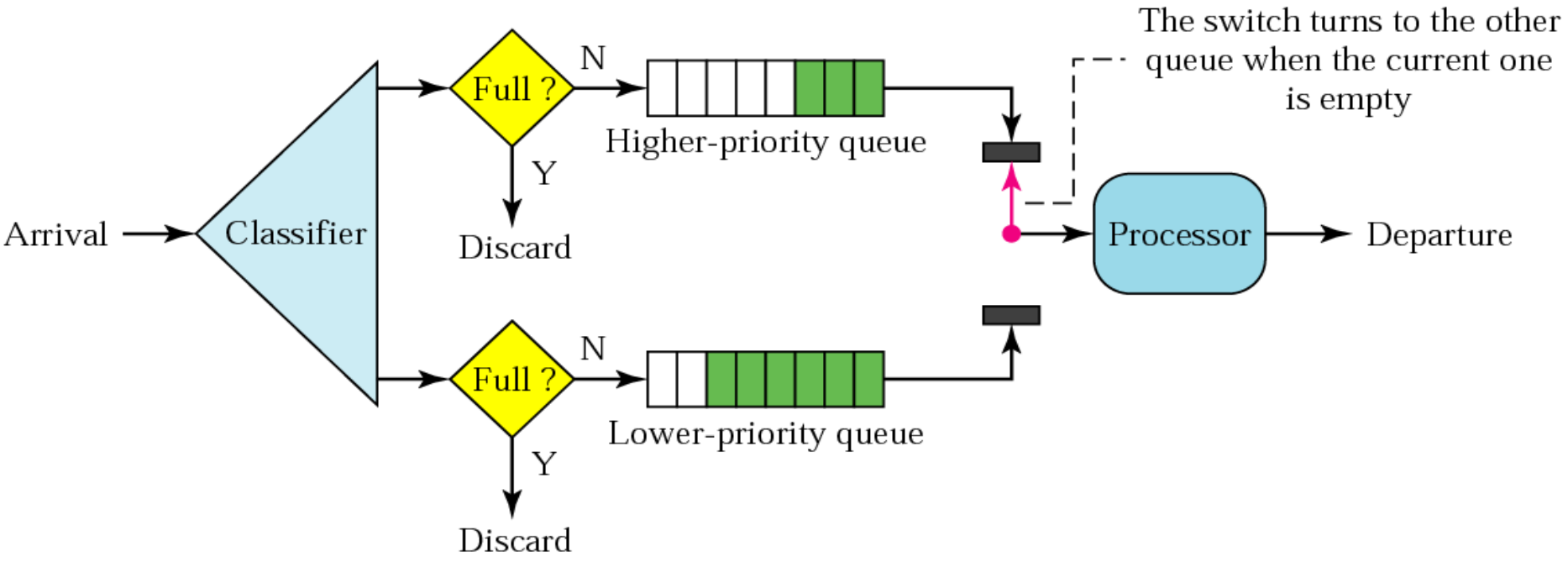
Explicit Signaling

- ✓ The node that experiences congestion can explicitly send a signal to the source or destination.
- ✓The explicit signaling method,however, is different from the choke packet method.
- ✓ In the choke packet method, a separate packet is used for this purpose
- ✓ In the explicit signaling method, the signal is included in the packets that carry data.

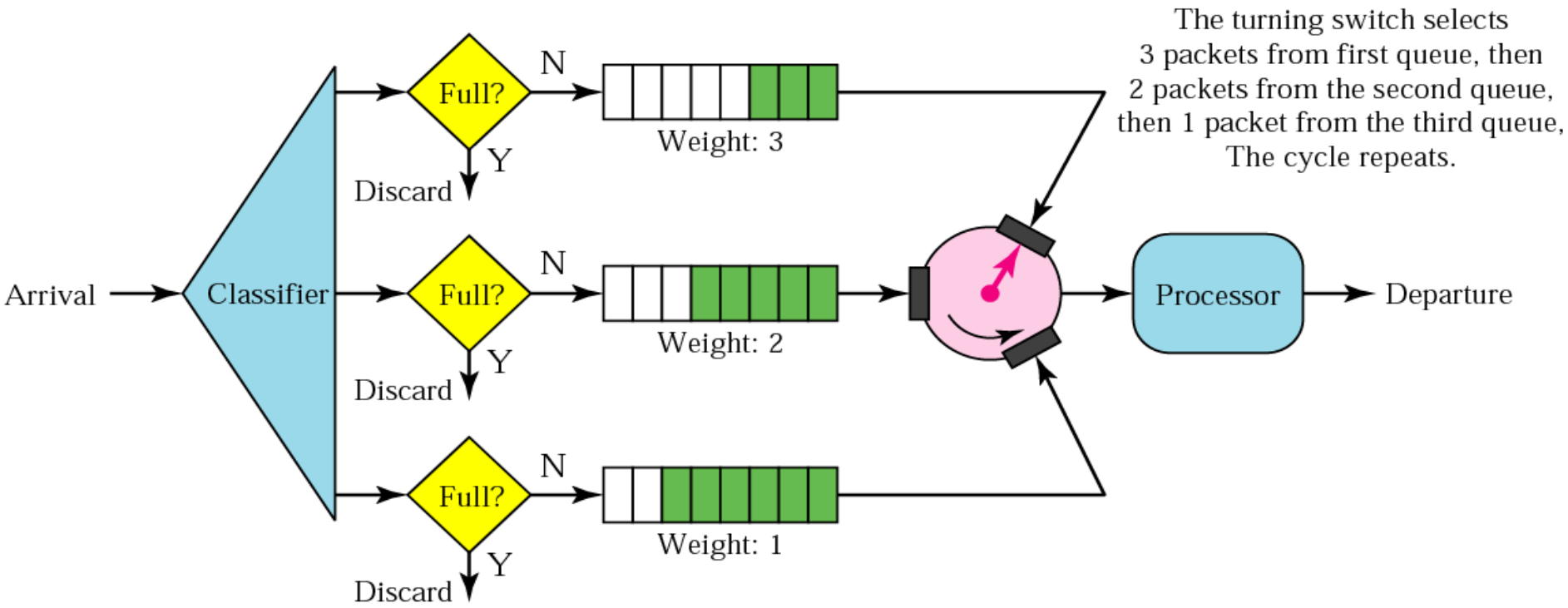
Congestion Control : FIFO Queue



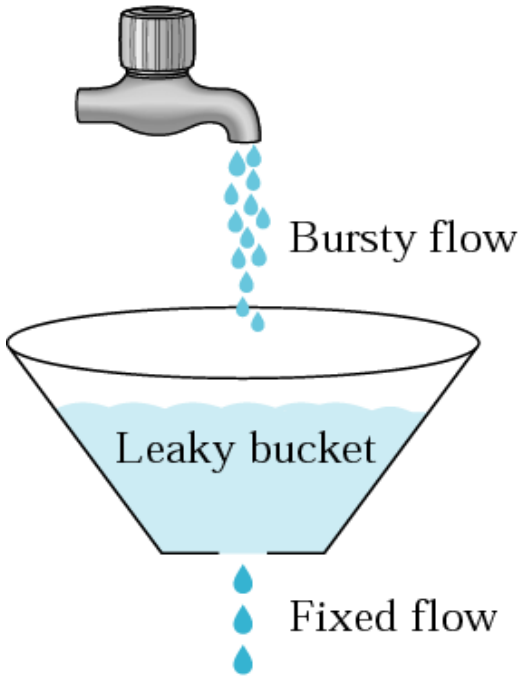
Congestion Control：Priority Queuing

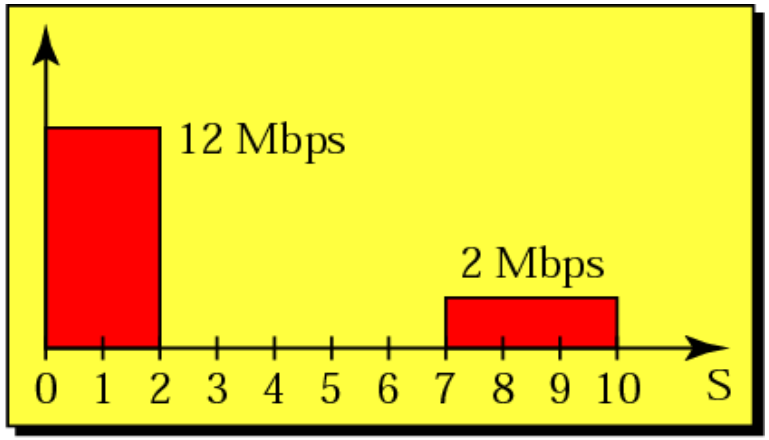


Congestion Control : Weighted Fair Queuing

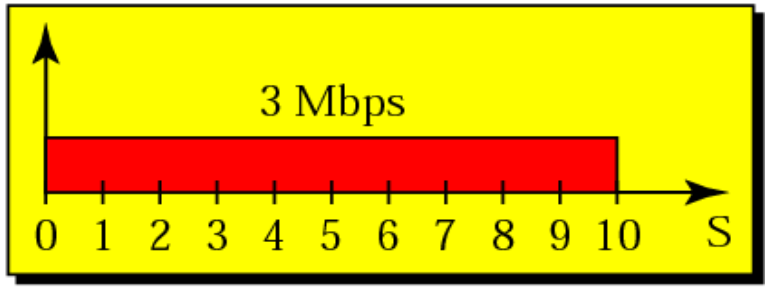


Congestion Control: Leaky Bucket



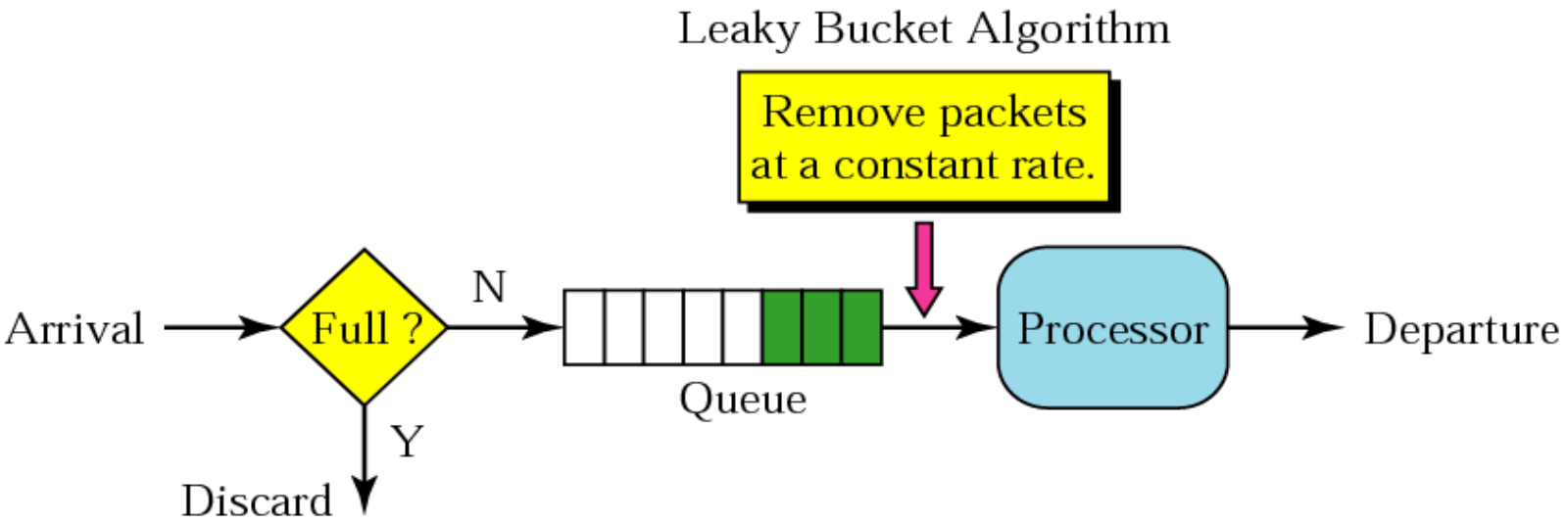


Bursty data

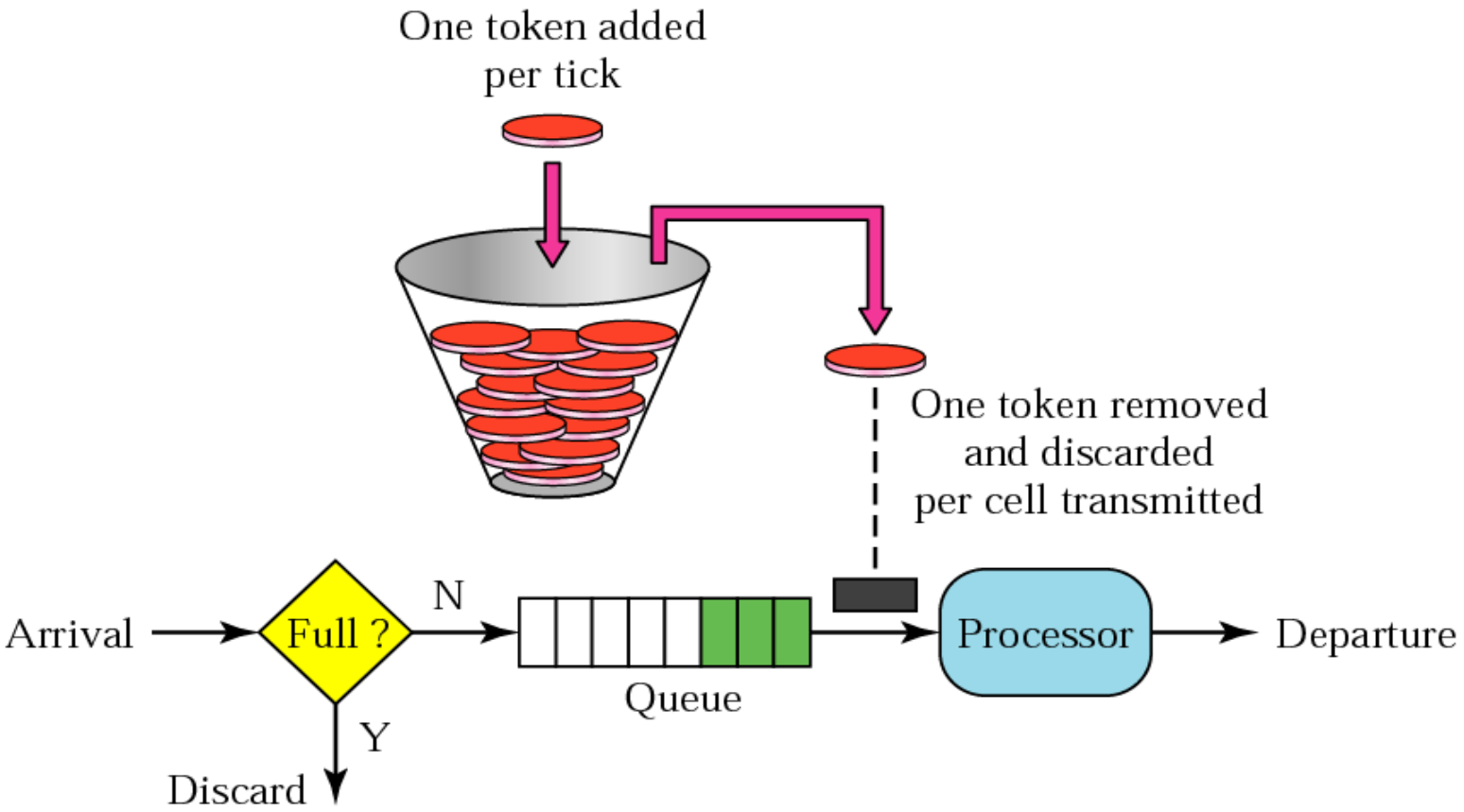


Fixed-rate data

Congestion Control: Leaky Bucket Implementation



Congestion Control: Token Bucket



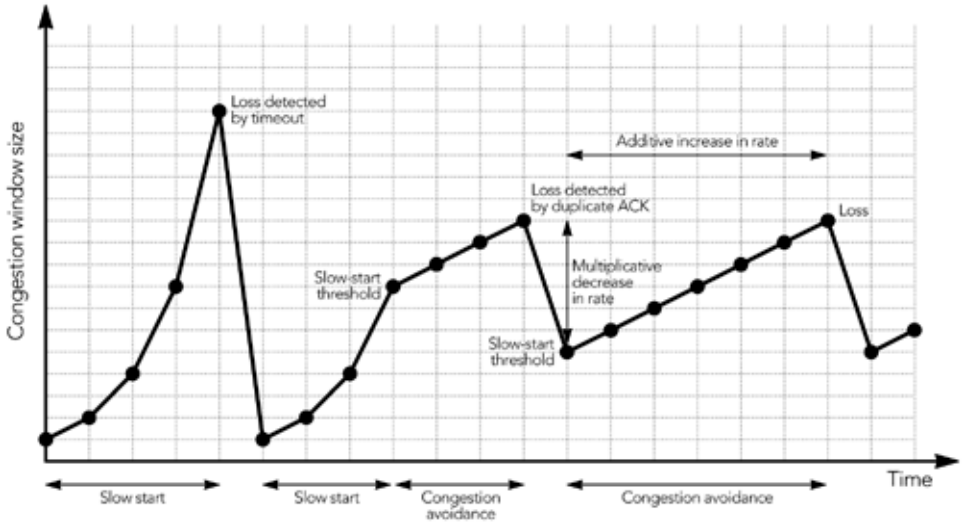
Congestion Control: Open Loop Approaches (Preventive)

- ✓Windows Policy: Type of window at sender may also affect congestion. Selective repeat is better than Go-Back-N.
- ✓Acknowledgement Policy: Policy set by receiver may also affect congestion. If receiver does not acknowledge every packet it receives, it may slow down the sender and help prevent congestion. Sending few ACK means imposing less load on Networks
- ✓Discard Policy: Discard less sensitive packets [in audio transmission] at routers.
- ✓Admission Policy: Switches in a flow first check the resource requirement of a flow before admitting it to the network. [Possibility of Future Congestion]

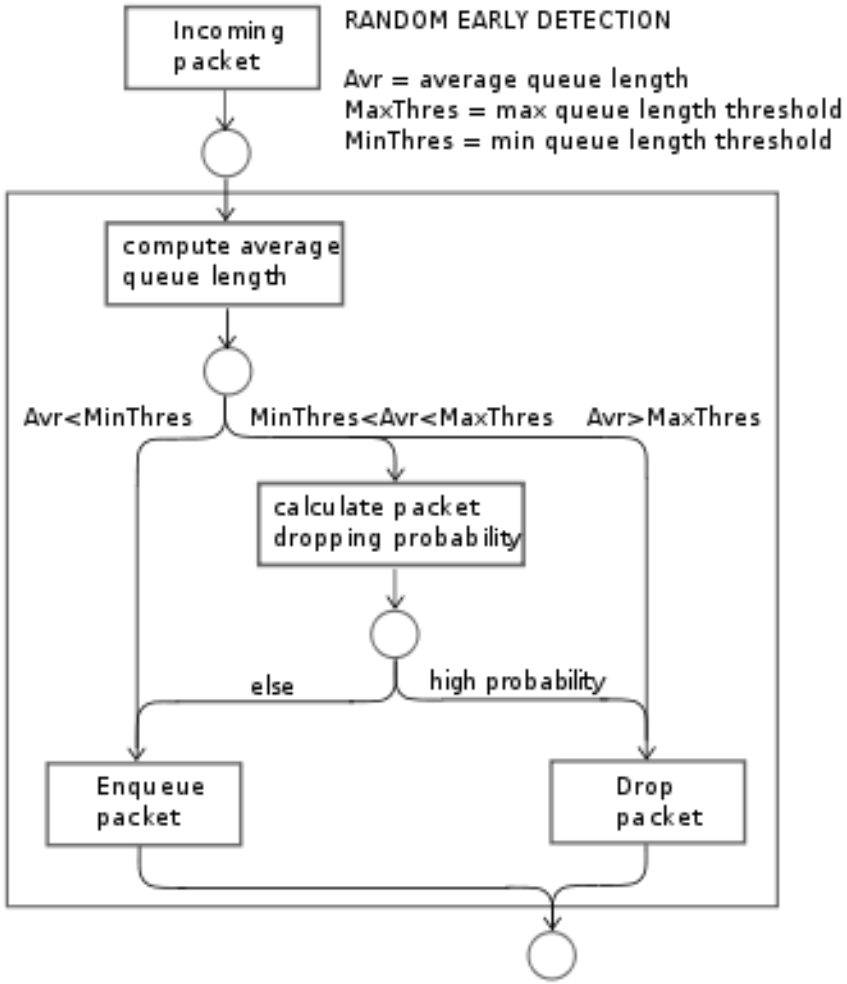
TCP Congestion Control : AIMD

- AIMD => Additive Increase Multiplicative Decrease.
- Feedback Control Algorithm Best Known for TCP Congestion Avoidance.
- AIMD Combines Linear growth of the Congestion Window with an Exponential reduction when a Congestion takes Place.

$$w(t+1) = \begin{cases} w(t) + a & \text{if congestion is not detected} \quad a > 0 \\ w(t) \times b & \text{if congestion is detected} \quad 0 < b < 1 \end{cases}$$



Random Early Detection



Thank You