COMPUTER NETWORKS

When too many packets are present in the network it causes packet delay and loss of packet which degrades the performance of the system. This situation is called congestion.

Congestion Control techniques in Network Layer

In the network layer, before the network can make Quality of service guarantees, it must know what traffic is being guaranteed. One of the main causes of congestion is that traffic is often bursty.

To understand this concept first we have to know little about traffic shaping.Traffic Shaping is a mechanism to control the amount and the rate of traffic sent to the network. Approach of congestion management is called Traffic shaping. Traffic shaping helps to regulate the rate of data transmission and reduces congestion.

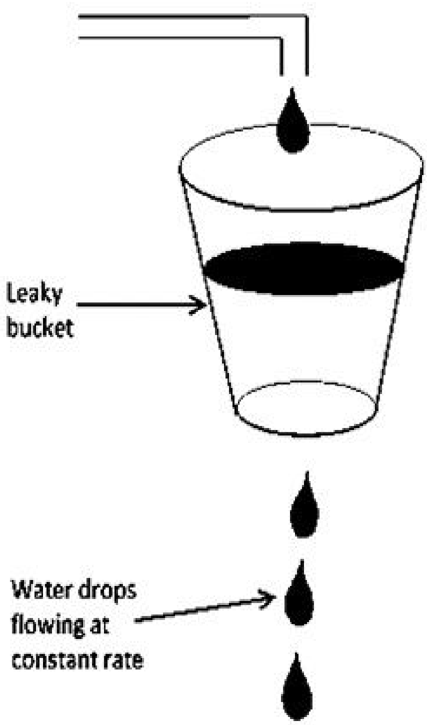
There are 2 types of traffic shaping algorithms:

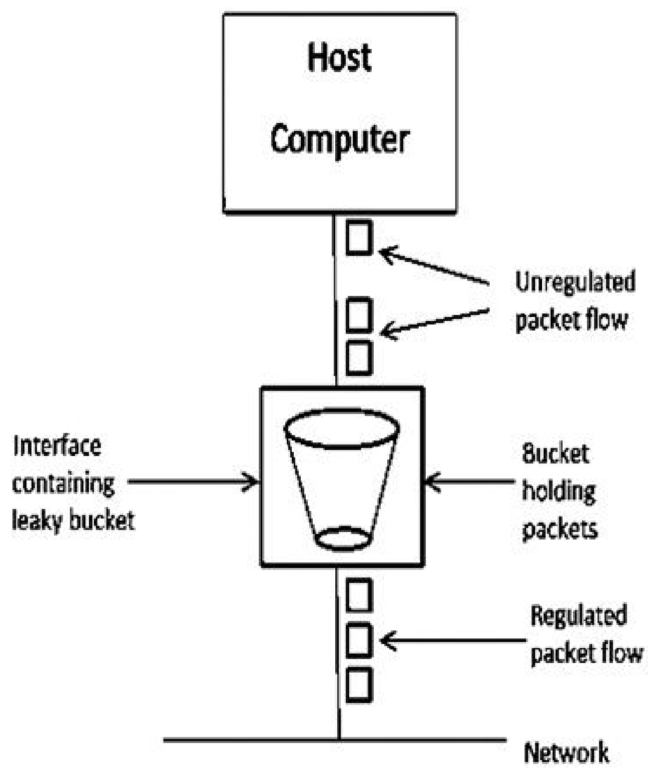
1.Leaky Bucket

2.Token Bucket

1.Leaky bucket algorithm:

the working condition of Leaky Bucket Algorithm −





Leaky Bucket Algorithm mainly controls the total amount and the rate of the traffic sent to the network.

Step 1− Let us imagine a bucket with a small hole at the bottom where the rate at which water is poured into the bucket is not constant and can vary but it leaks from the bucket at a constant rate.

Step 2− So (up to water is present in the bucket), the rate at which the water leaks does not depend on the rate at which the water is input to the bucket.

Step 3− If the bucket is full, additional water that enters into the bucket that spills over the sides and is lost.

Step 4− Thus the same concept applied to packets in the network. Consider that data is coming from the source at variable speeds. Suppose that a source sends data at 10 Mbps for 4 seconds. Then there is no data for 3 seconds. The source again transmits data at a rate of 8 Mbps for 2 seconds. Thus, in a time span of 8 seconds, 68 Mb data has been transmitted.

That's why if a leaky bucket algorithm is used, the data flow would be 8 Mbps for 9 seconds. Thus, the constant flow is maintained.

2.Token Bucket Algorithm

The leaky bucket algorithm enforces output patterns at the average rate, no matter how busy the traffic is. So, to deal with the more traffic, we need a flexible algorithm so that the data is not lost. One such approach is the token bucket algorithm.

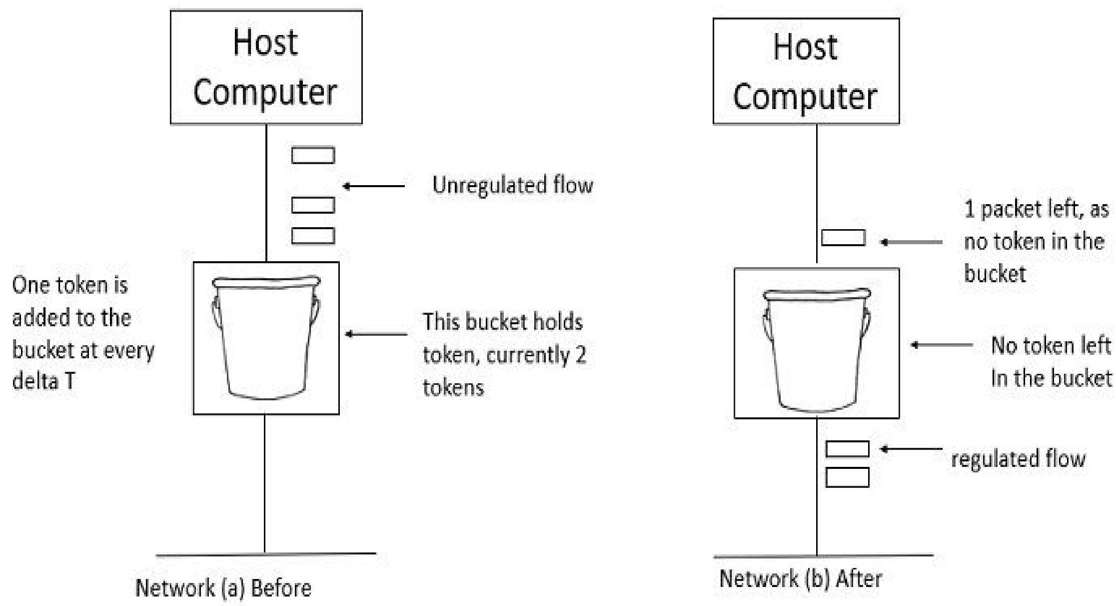
Let us understand this algorithm step wise as given below −

Step 1− In regular intervals tokens are thrown into the bucket f.

Step 2− The bucket has a maximum capacity f.

Step 3− If the packet is ready, then a token is removed from the bucket, and the packet is sent.

Step 4− Suppose, if there is no token in the bucket, the packet cannot be sent



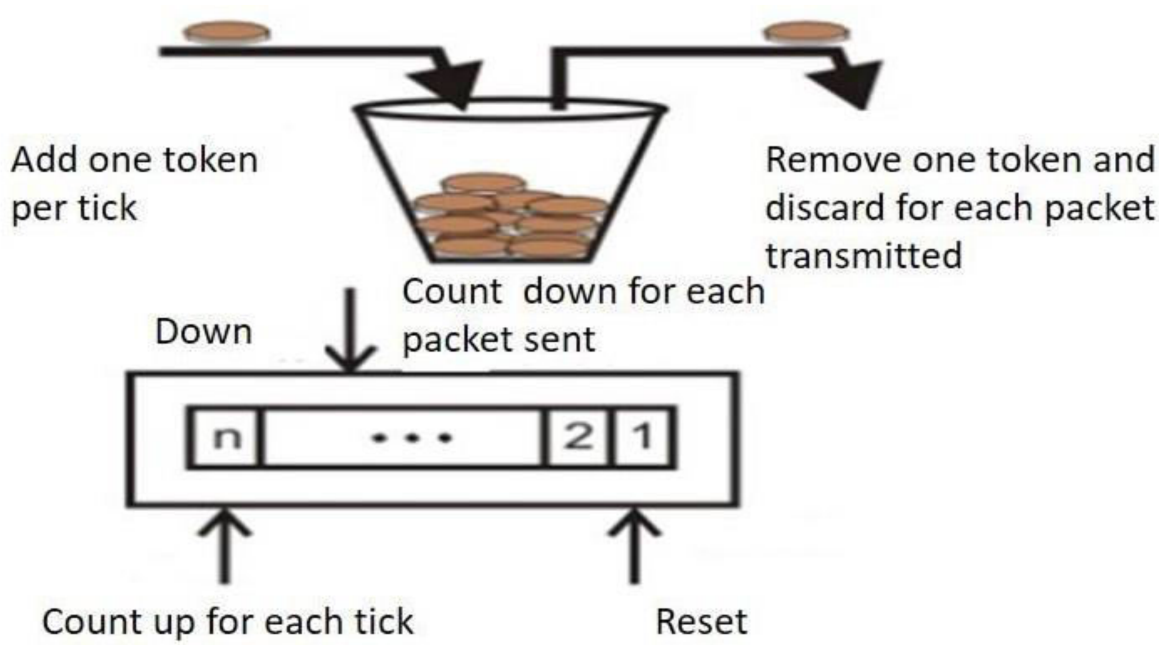
In figure (a) the bucket holds two tokens, and three packets are waiting to be sent out of the interface.

In Figure (b) two packets have been sent out by consuming two tokens, and 1 packet is still left.

When compared to Leaky bucket the token bucket algorithm is less restrictive that means it allows more traffic. The limit of busyness is restricted by the number of tokens available in the bucket at a particular instant of time.

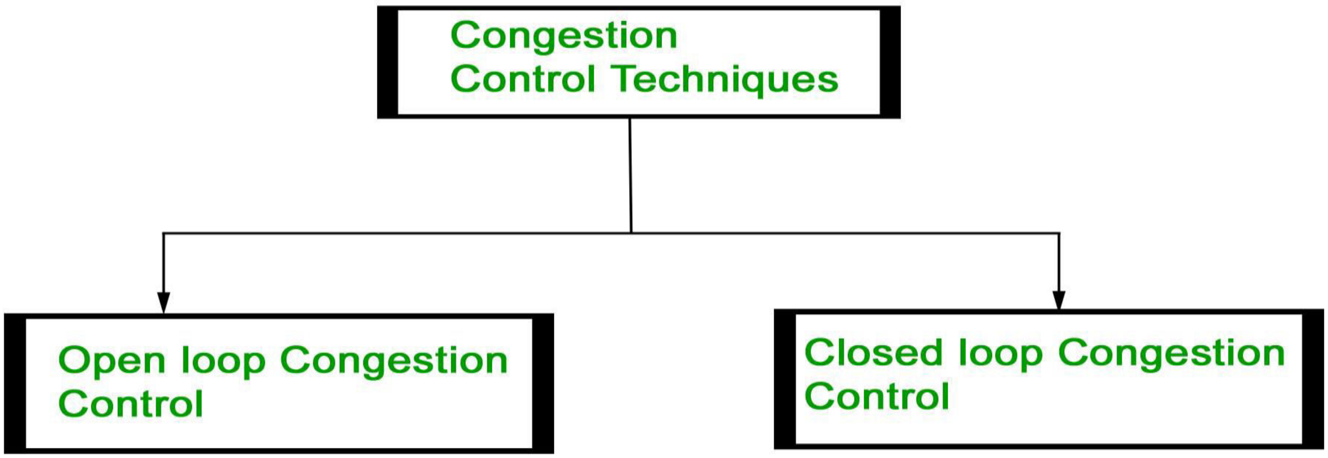
The implementation of the token bucket algorithm is easy − a variable is used to count the tokens. For every t seconds the counter is incremented and then it is decremented whenever a packet is sent. When the counter reaches zero, no further packet is sent out.

This is shown in below given diagram −



Congestion Control techniques in Transport Layer

Congestion control refers to the techniques used to control or prevent congestion. Congestion control techniques can be broadly classified into two categories:



Open Loop Congestion Control

Open loop congestion control policies are applied to prevent congestion before it happens. The congestion control is handled either by the source or the destination.

Policies adopted by open loop congestion control –

1.**Retransmission Policy :**

It is the policy in which retransmission of the packets are taken care of. If the sender feels that a sent packet is lost or corrupted, the packet needs to be retransmitted. This transmission may increase the congestion in the network.

To prevent congestion, retransmission timers must be designed to prevent congestion and also able to optimize efficiency.

2.**Window Policy :**

The type of window at the sender's side may also affect the congestion. Several packets in the Go-back-n window are re-sent, although some packets may be received successfully at the receiver side. This duplication may increase the congestion in the network and make it worse.

Therefore, Selective repeat window should be adopted as it sends the specific packet that may have been lost.

3.**Discarding Policy :**

A good discarding policy adopted by the routers is that the routers may prevent congestion and at the same time partially discard the corrupted or less sensitive packages and also be able to maintain the quality of a message.

In case of audio file transmission, routers can discard less sensitive packets to prevent congestion and also maintain the quality of the audio file.

4.**Acknowledgment Policy :**

Since acknowledgements are also the part of the load in the network, the acknowledgment policy imposed by the receiver may also affect congestion. Several approaches can be used to prevent congestion related to acknowledgment.

The receiver should send acknowledgement for N packets rather than sending acknowledgement for a single packet. The receiver should send an acknowledgment only if it has to send a packet or a timer expires.

5. **Admission Policy :**

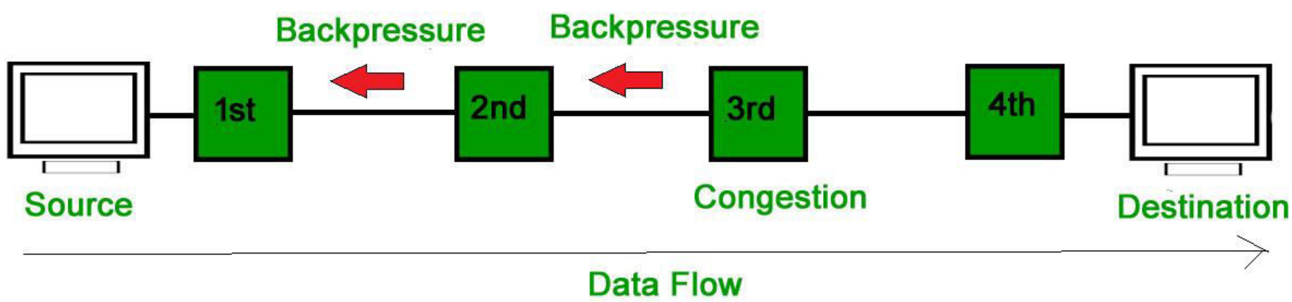
In admission policy a mechanism should be used to prevent congestion. Switches in a flow should first check the resource requirement of a network flow before transmitting it further. If there is a chance of a congestion or there is a congestion in the network, router should deny establishing a virtual network connection to prevent further congestion.

All the above policies are adopted to prevent congestion before it happens in the network.

Closed Loop Congestion Control

Closed loop congestion control techniques are used to treat or alleviate congestion after it happens. Several techniques are used by different protocols; some of them are:

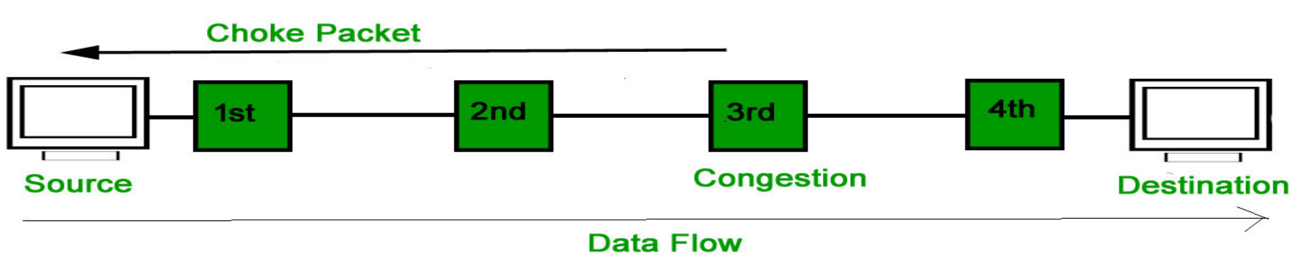
1. Backpressure :
Backpressure is a technique in which a congested node stops receiving packets from upstream node. This may cause the upstream node or nodes to become congested and reject receiving data from above nodes. Backpressure is a node-to-node congestion control technique that propagate in the opposite direction of data flow. The backpressure technique can be applied only to virtual circuit where each node has information of its above upstream node.



In above diagram the 3rd node is congested and stops receiving packets as a result 2nd node may be get congested due to slowing down of the output data flow. Similarly 1st node may get congested and inform the source to slow down.

2. **Choke Packet Technique :**

Choke packet technique is applicable to both virtual networks as well as datagram subnets. A choke packet is a packet sent by a node to the source to inform it of congestion. Each router monitors its resources and the utilization at each of its output lines. Whenever the resource utilization exceeds the threshold value which is set by the administrator, the router directly sends a choke packet to the source giving it a feedback to reduce the traffic. The intermediate nodes through which the packets has traveled are



not warned about congestion.

3 **Implicit Signaling :**
In implicit signaling, there is no communication between the congested nodes and the source.

The source guesses that there is congestion in a network. For example when sender sends several packets and there is no acknowledgment for a while, one assumption is that there is a congestion.

4**. Explicit Signaling :**

In explicit signaling, if a node experiences congestion it can explicitly sends a packet to the source or destination to inform about congestion. The difference between choke packet and explicit signaling is that the signal is included in the packets that carry data rather than creating a different packet as in case of choke packet technique.

Explicit signaling can occur in either forward or backward direction.

- **Forward Signaling** :In forward signaling, a signal is sent in the direction of the congestion. The destination is warned about congestion. The receiver in this case adopt policies to prevent further congestion.
- **Backward Signaling** :In backward signaling, a signal is sent in the opposite direction of the congestion. The source is warned about congestion and it needs to slow down.

Difference between Flow Control and Congestion Control

Flow Control and **Congestion Control** are traffic controlling methods for different situations. The main difference between flow control and congestion control is that, In flow control, rate of traffic received from a sender can be controlled by a receiver. On the other hand, In congestion control, rate of traffic from sender to the network is controlled. Let’s see the difference between flow control and congestion control:

S.NO	Flow Control	Congestion Control

1.	Traffic from sender to receiver is controlled, to avoid overwhelming the slow receiver.	Traffic entering the network from a sender is controlled by reducing rate of packets. Here, the sender has to control/modulate his own rate to achieve optimal network utilization.
2.	Flow control is typically used in data link layer.	Congestion control is applied in network and transport layer.
3.	In this, Receiver’s data is prevented from being overwhelmed.	In this, Network is prevented from congestion.
4.	In flow control, sender needs to take measures to avoid receiver from being overwhelmed depending on feedback from receiver and also in absence of any feedback.	In this, many algorithms designed for transport layer/network layer define how endpoints should behave to avoid congestion.
5.	Types of Flow control are 1. Stop and Wait – For every frame transmitted, sender expects ACK from receiver. Sliding Window – ACK needed only after sender transmits data until window is full, which is allocated initially by receiver.	Mechanisms designed to prevent network congestions are 1. Network Queue Management 2. Explicit Congestion Notification 3. TCP