Congestion Control in Computer Networks

What is **congestion**?

A state occurring in network layer when the message traffic is so heavy that it slows down network response time.

Effects of Congestion

- As delay increases, performance decreases.
- If delay increases, retransmission occurs, making situation worse.

9.10.1. Need of Congestion Control

It is not possible to completely avoid the congestion but it is necessary to control it. Congestion leads to a large queue length, which results in buffer overflow and loss of packets. So congestion control is necessary to ensure that the user gets the negotiated QoS (quality of service).

9.10.2. Causes of Congestion

Some of the causes of congestion are as follows :

(*i*) If suddenly a stream of packets start coming on three or four input lines which all need the same output line. Then a queue is built up. If the memory capacity is not sufficient to hold all these packets, some of them are lost. This is shown in figure 9.16(*a*).

Note that increasing the memory to infinity also does not solve the problem, in fact it worsens.

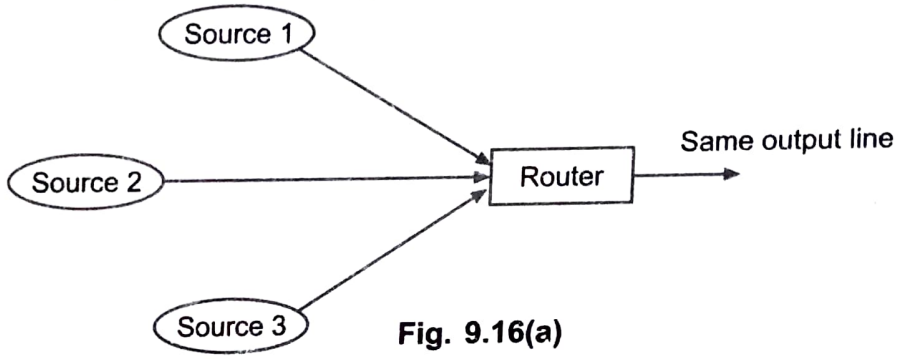


Fig. 9.16(a)

(*ii*) Congestion is caused by slow links. The problem will be solved when high speed links become available. It is not always the case, sometimes increases in link bandwidth can aggravate the congestion problem because higher speed links may make the network more unblanaced. For the configuration showed in figure 9.16 (*b*), if both of the two sources begin to send to destination 1 at their peak rate, congestion will occur at the switch. High speed links can make the congestion condition in the switch worse.

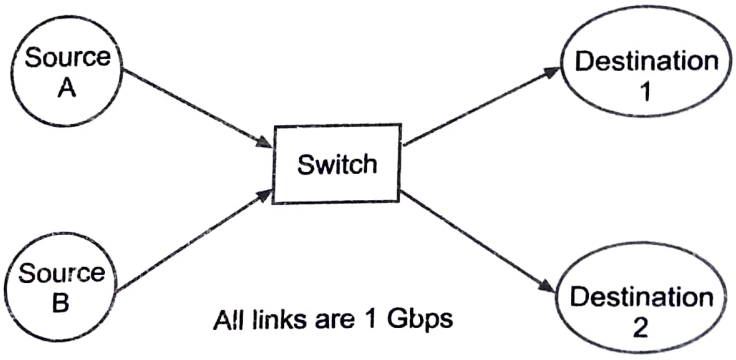


Fig. 9.16(b) Network with high speed links

(*iii*) Congestion is caused by slow processors. The problem is solved when processor speed is improved. Faster processors transmit more data in unit time. If several nodes begin to transmit to one destination simultaneously at their peak rate, the target is overwhelmed soon.

(*iv*) Congestion can make itself worse. If a router does not have any free buffers, it should ignore (discard) new packets arriving at it. But when a packet is discarded, the sender may retransmit it many times because it is not receiving the acknowledgment of the packet. This multiple transmission of packets forces the congestion to take place at the sending end.

9.10.4. Principle of Congestion Control

The solutions to congestion problems can be divided into two categories or groups as open loop solutions and closed loop solutions. Congestion control refers to the techniques and mechanisms which can either prevent congestion from happening or remove congestion after it has taken place. The open loop congestion control is based on the prevention of congestion whereas the closed loop solutions are for removing the congestion.

Figure 9.17 shows the classification of congestion control schemes and various policies used in open loop and closed loop groups.

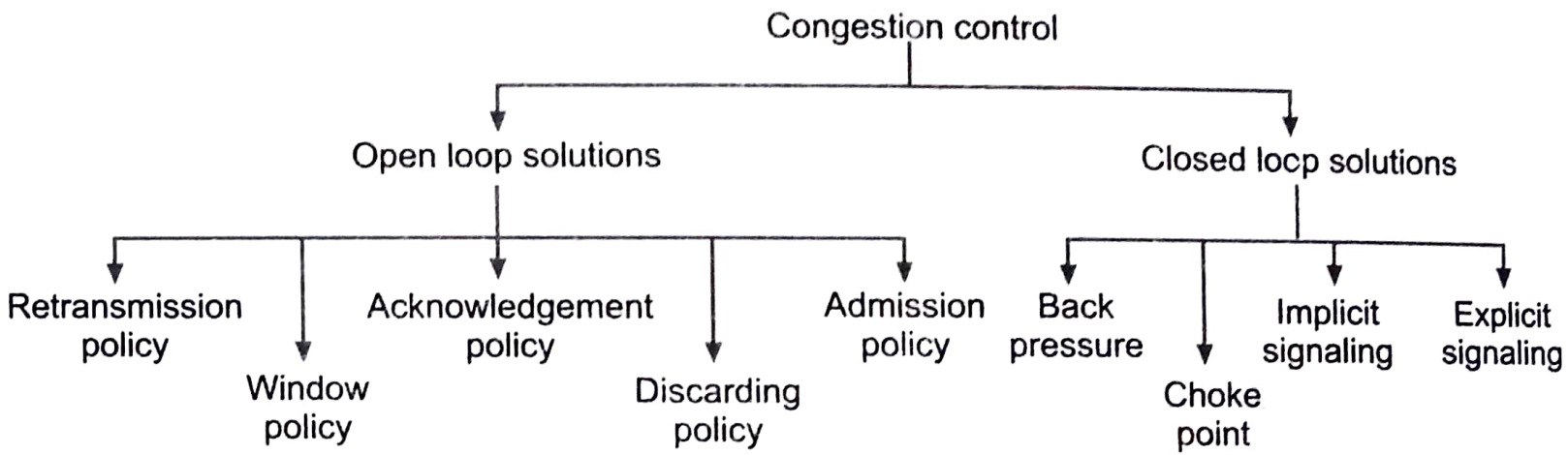
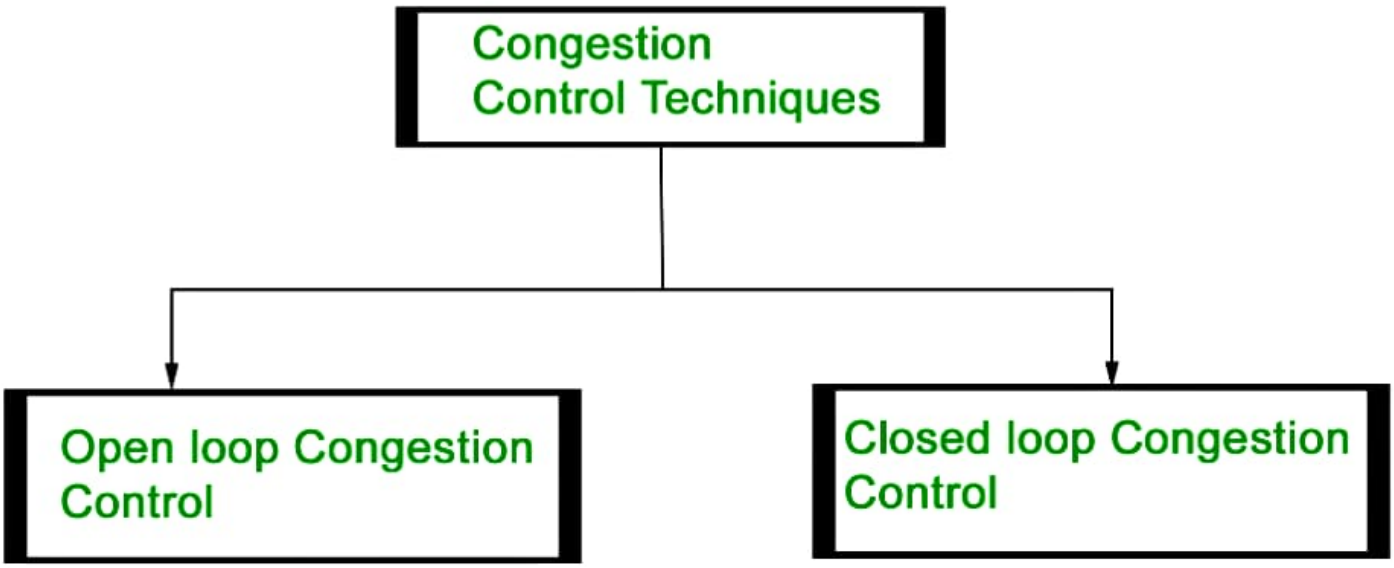


Fig. 9.17 Classification of congestion control schemes

Congestion Control techniques in Computer Networks

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. 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 side may also affect the congestion. Several packets in the Go-back-n window are resent, although some packets may be received successfully at the receiver side. This duplication may increase the congestion in the network and making 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 discards the corrupted or less sensitive package and also 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 acknowledgement are also the part of the load in 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 a acknowledgment only if it has to sent a packet or a timer expires.

5. **Admission Policy :**

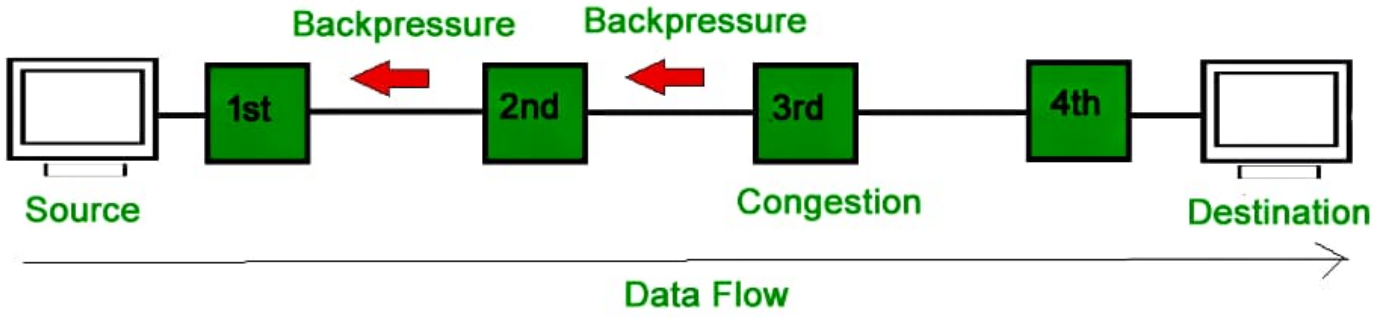
In admission policy a mechanism should be used to prevent congestion. Switches in a flow should first check the resource requirement of a network flow before transmitting it further. If there is a chance of a congestion or there is a congestion in the network, router should deny establishing a virtual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

Closed Loop Congestion Control

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

1. **Backpressure :**

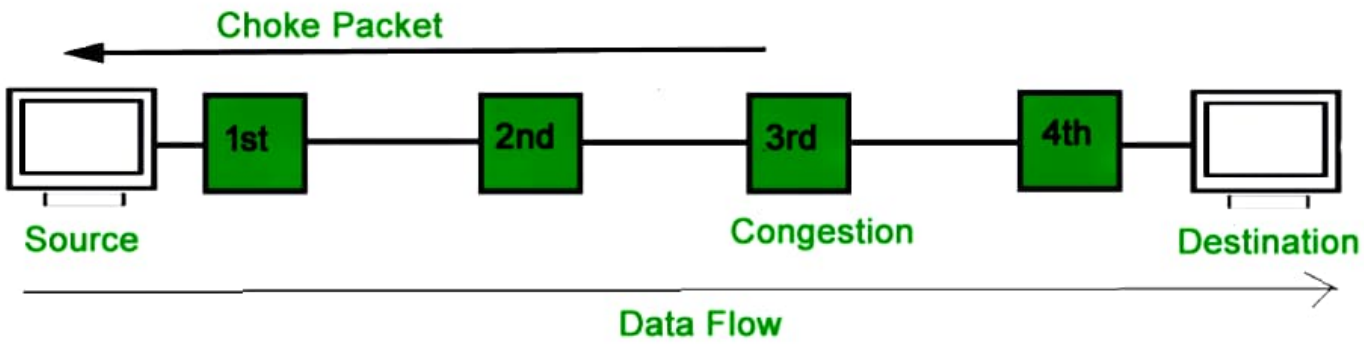
   Backpressure is a technique in which a congested node stop receiving packet from upstream node. This may cause the upstream node or nodes to become congested and rejects receiving data from above nodes. Backpressure is a node-to-node congestion control technique that propagate in the opposite direction 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 informs 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 monitor 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 different packet as in case of choke packet technique.

Explicit signaling can occur in either forward or backward direction.

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