TRAFFIC CONTROL & QOS

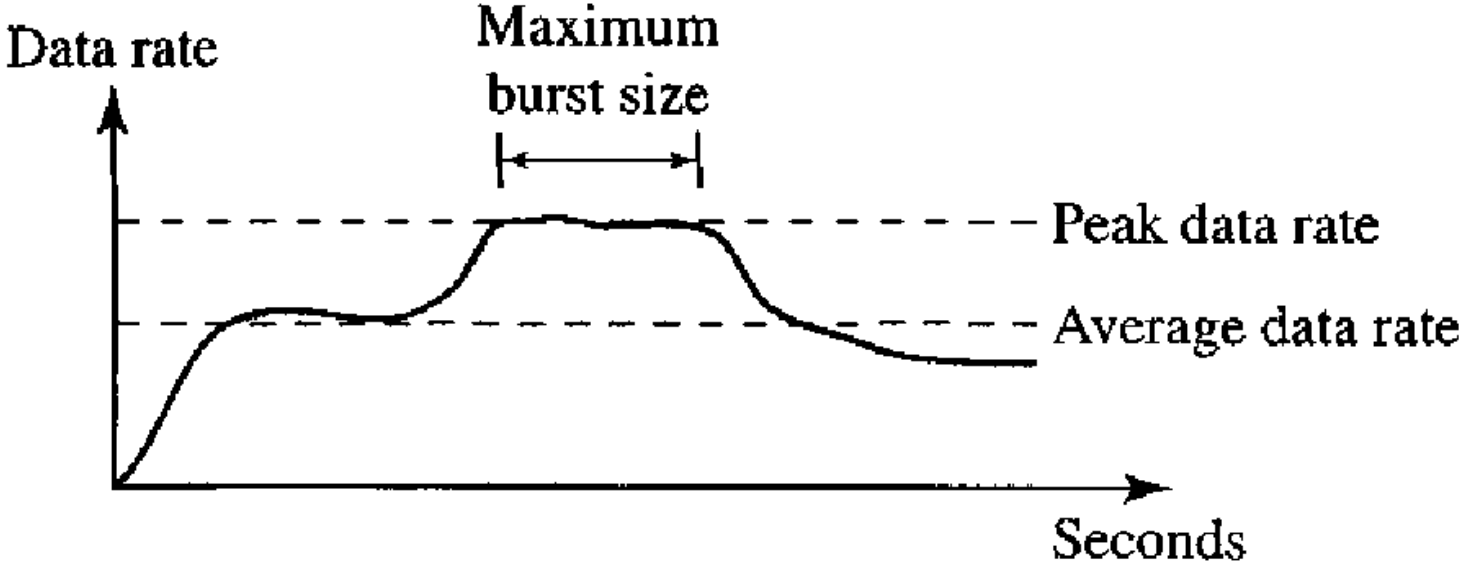
In networking terms,’ Traffic’ is basically data which flows throughout various networks consisting of LANs, WANs etc.

This data is generally in the form of small units called ‘Packets.’

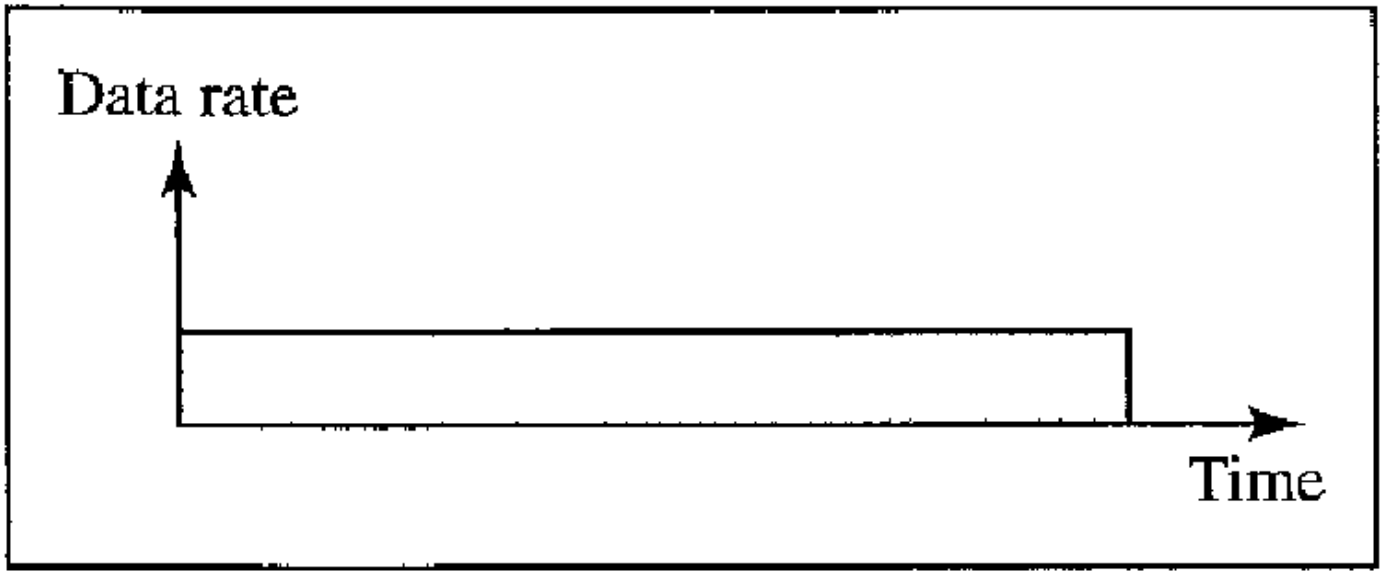
Types of traffic

- Constant Bit Rate (CBR)
- Variable Bit Rate (VBR)
- Bursty Traffic

Data Traffic Descriptors

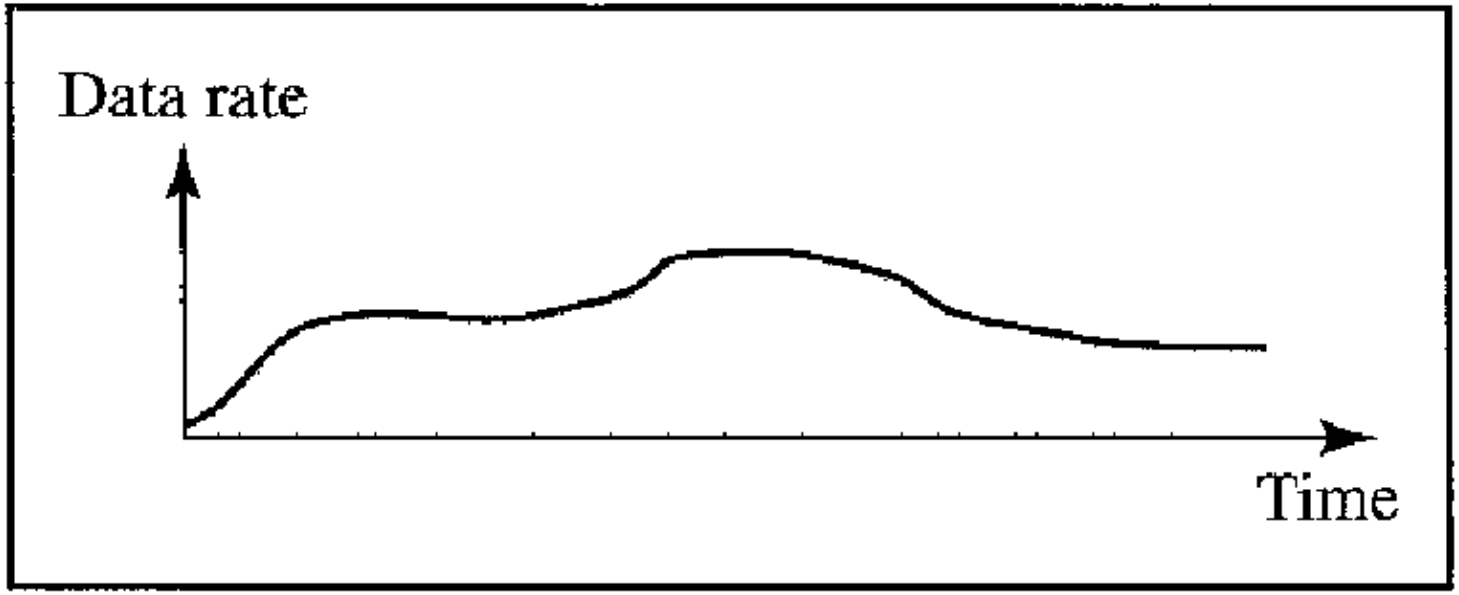


CBR



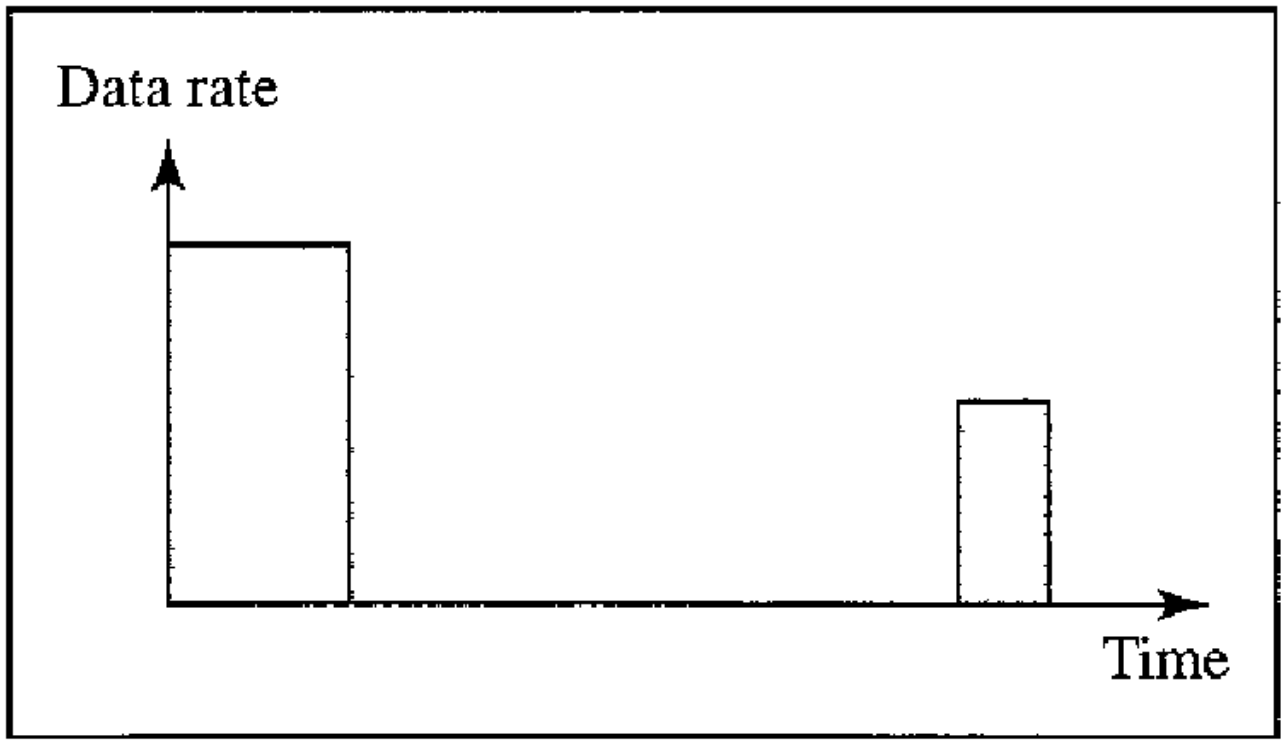
a. Constant bit rate

VBR



b. Variable bit rate

Bursty



c. Bursty

Congestion in Network

- What is it?
- Why is it?
- How to avoid it?

Congestion

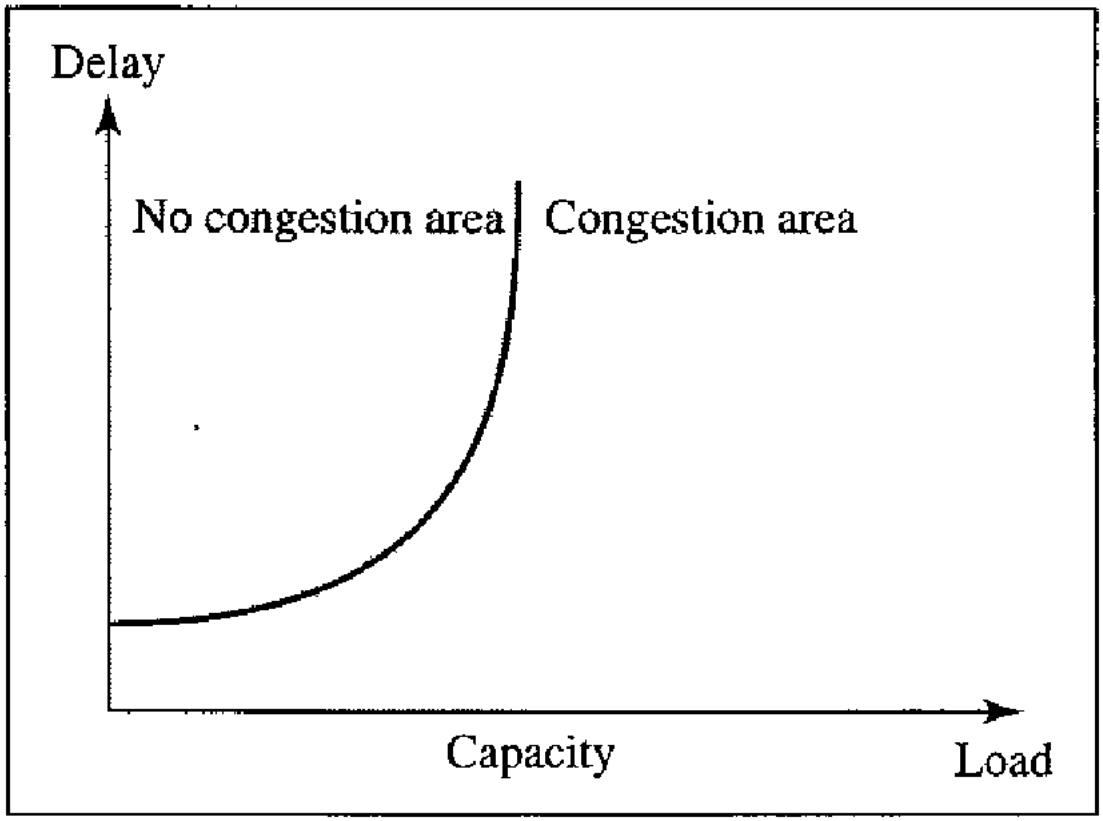
- If the number of packets sent to a network are more than its capacity to handle them,congestion is said to have taken place.
- It can occur due to various issues ,most significant being ‘Queues at routers’.
- Network Performance is seriously affected by congestion.

- Network performance is measured with respect to two simple factors:

1)Delay.

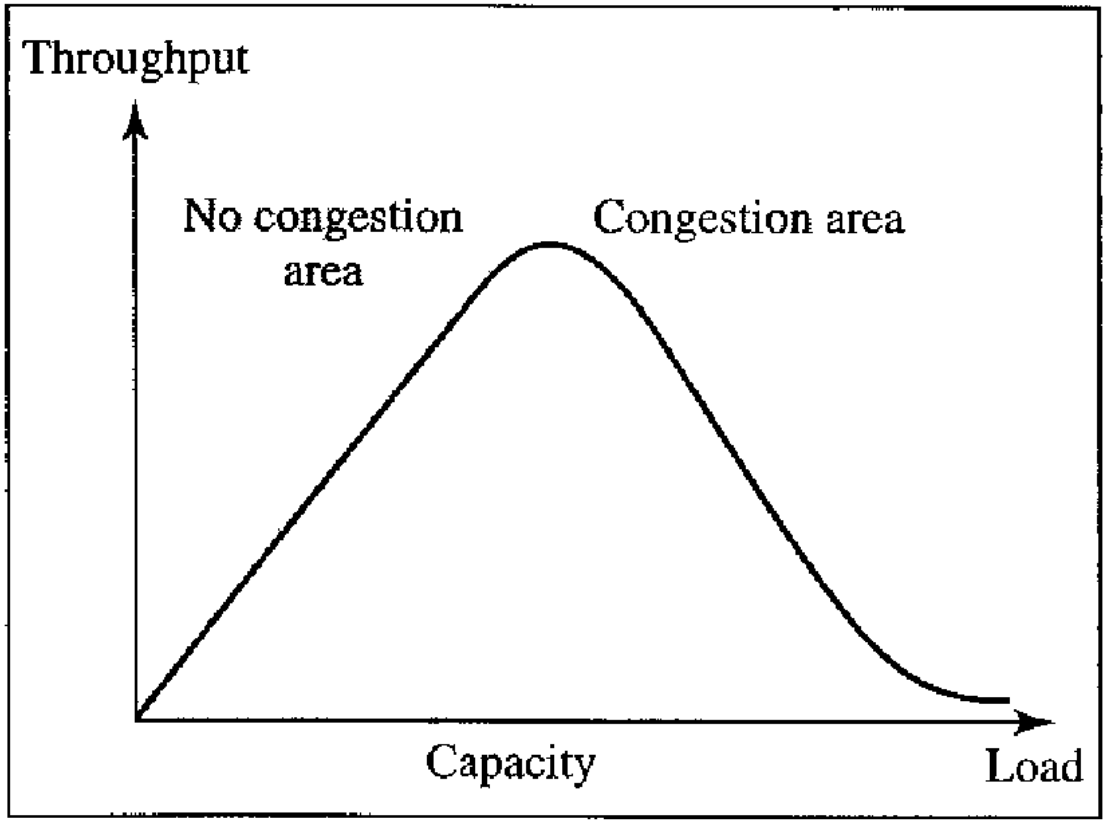
2)Throughput.

Packet Delay



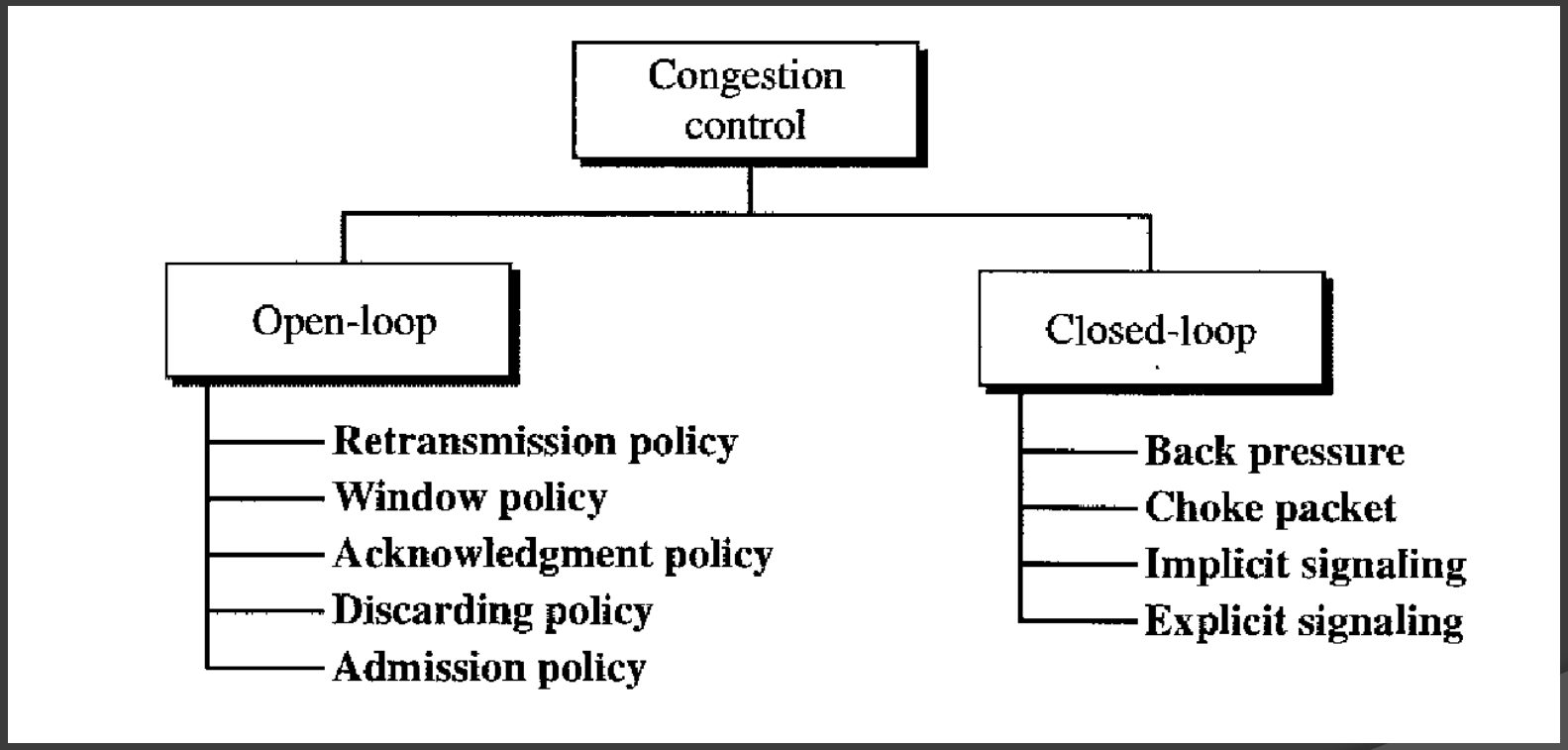
a. Delay as a function of load

Throughput



b. Throughput as a function of load

Congestion Control Techniques



Open Loop Congestion Control

- To prevent congestion ***before*** it happens in any particular network.
- It is performed either by source or destination present within the network.

Retransmission Policy

- Retransmission increases congestion in network as packet is retransmitted if no acknowledgement is received.
- Good policy can avoid it.
- Proper timer periods can help reduce congestion.

Window Policy

- The type of window selected also affects congestion.
- Selective Repeat window is much better than Go-Back-N window as only required packets are resent.
- Window Size also has to be selected appropriately.

Acknowledgement Policy

- ACKs increase load on network
- Various ACK policies
  - ACK sent only if there is a data packet to be sent
  - ACK sent after special timer goes off
  - ACK sent for N packets together

Discarding Policy

- This policy can be used but with caution so that it doesn't affect quality of network.
- 'How many and which packets can be discarded?' should be considered.
- Ex: Audio file transmission

Admission Policy

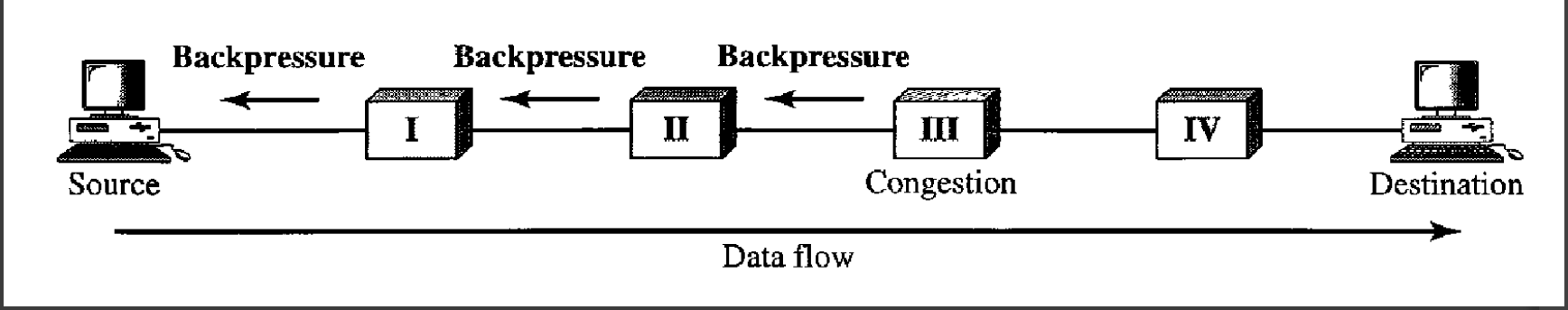
- In Various Networks,this policy helps considerably in controlling congestion.
- Here,the router refuses to establish new connection if there is a possibility of congestion within the network.

Closed Loop Congestion Control

- In this method,we try to alleviate congestion ***after*** it happens.

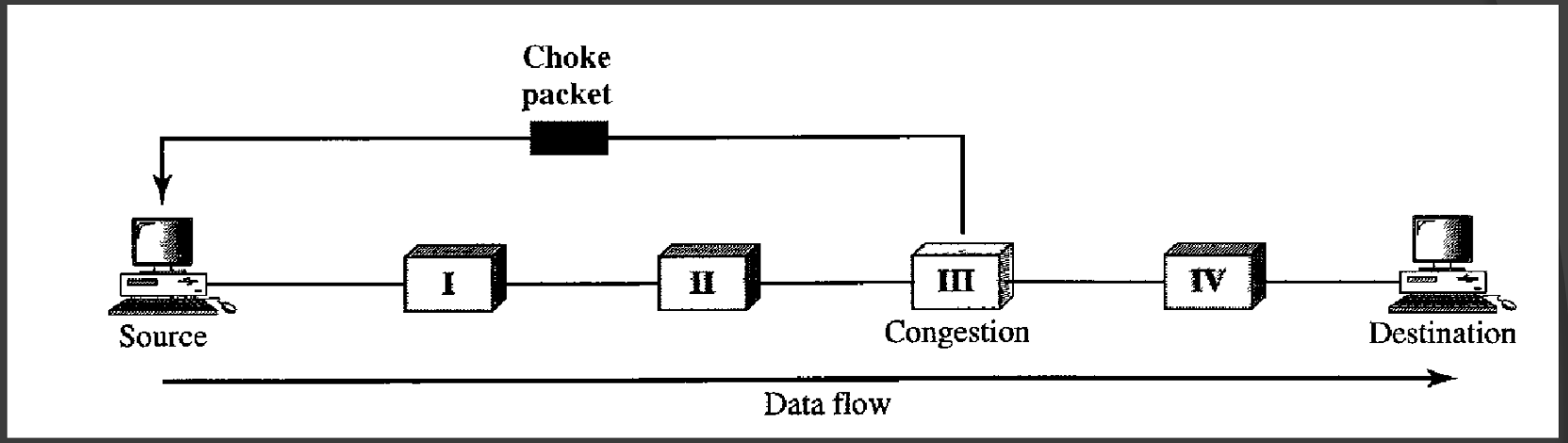
- Useful when open-loop methods seem to fail.

Backpressure



- Node to Node congestion control
- Travels in the opposite direction of data flow
- Only in virtual circuit networks (as we **have to** know the upstream router)

Choke Packet



- Warning directly to the source (not to upstream router)
- Applied to packet switched networks
- Intermediate nodes do not take any action

Implicit Signaling

- No communication between source and congested node
- Delay in ACKs --- A sign of congestion
- It is guessed by the source which takes appropriate measures to reduce congestion.

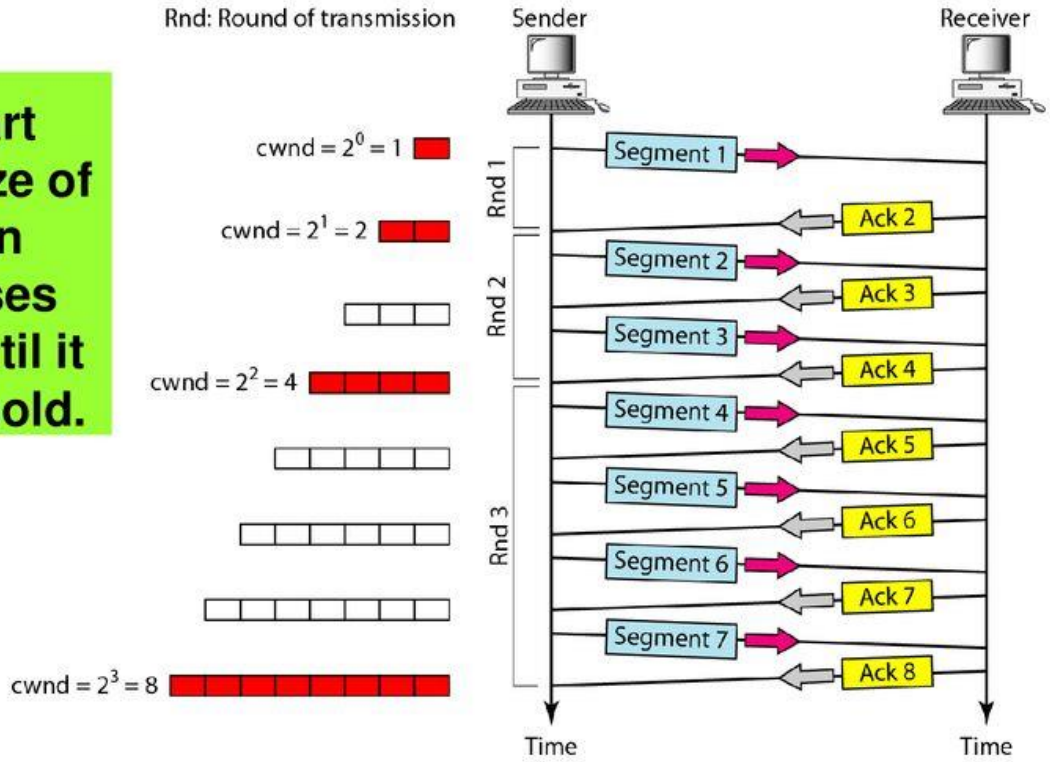
Explicit Signaling

- Congested node communicates with source or destination
- Here,congestion info. is embedded in data packet,unlike choke packet method;where separate packet is used
- Not like choke packet
  - Backward Signaling – to source
  - Forward Signaling – to destination

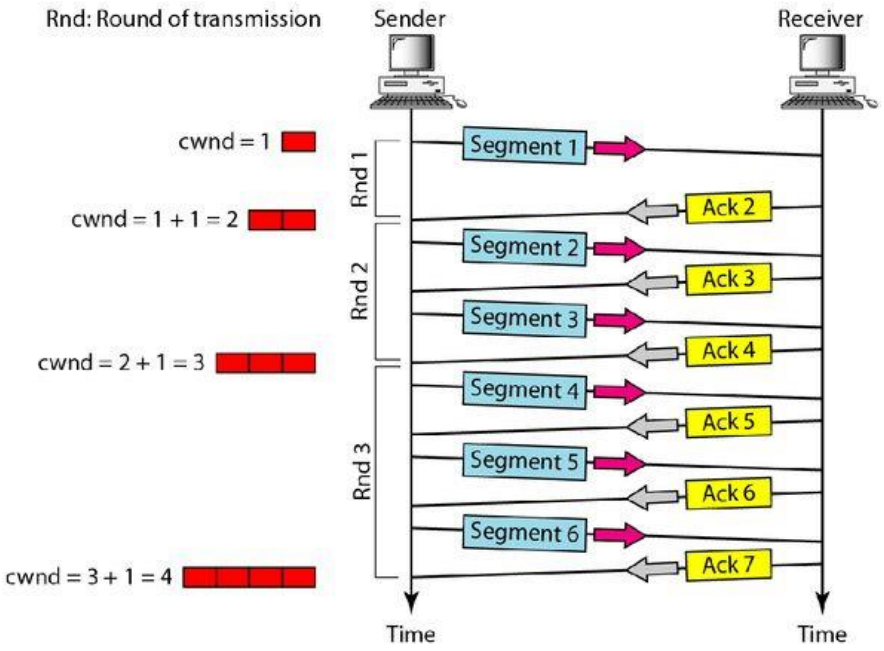
EXAMPLE Congestion Control in TCP

Slow start, exponential increase

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



Congestion avoidance, additive increase



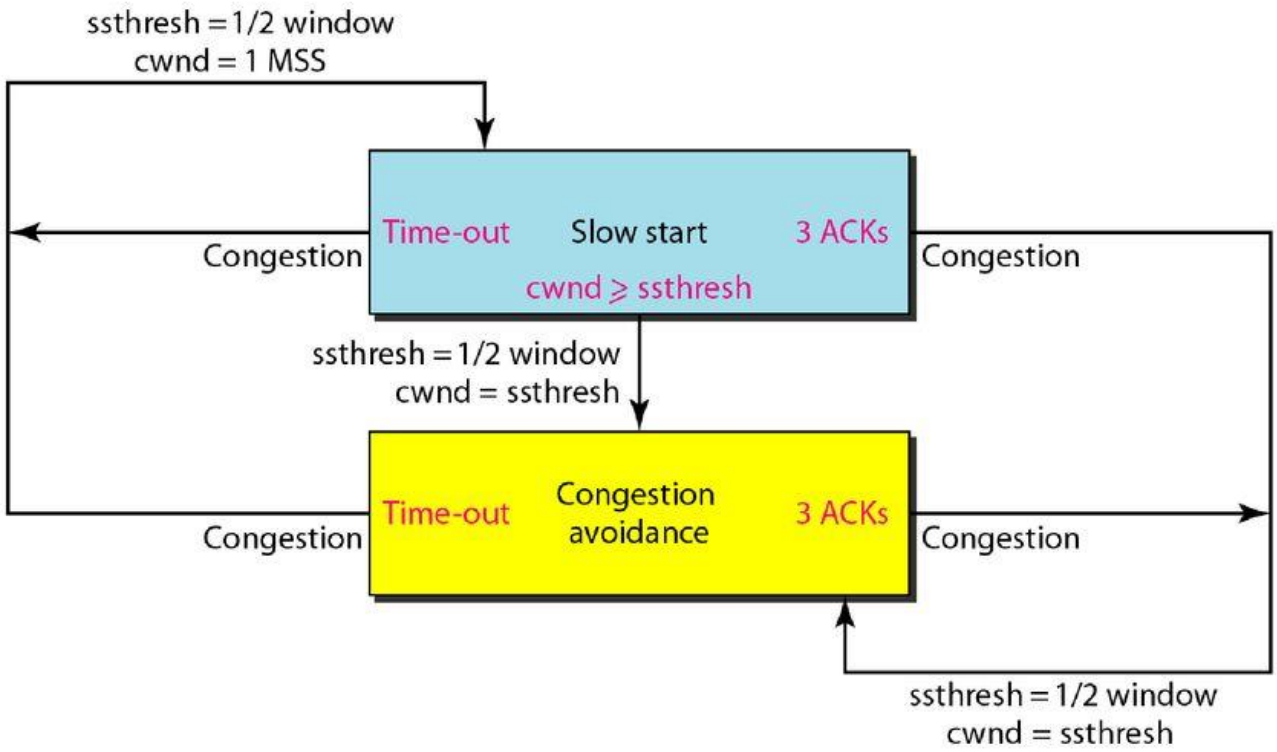
In the congestion avoidance algorithm, the size of the congestion window increases additively until congestion is detected.

Note

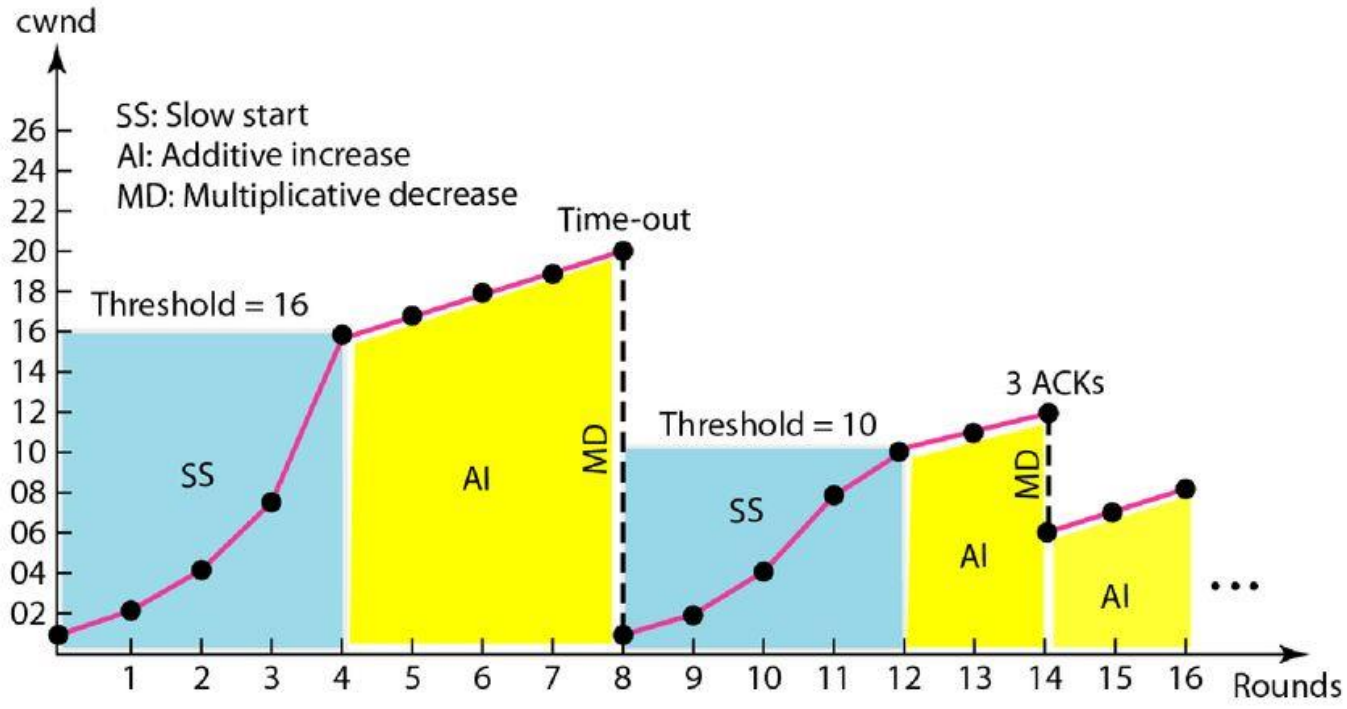
An implementation reacts to congestion detection in one of the following ways:

- **If detection is by time-out, a new slow start phase starts.**
- **If detection is by three ACKs, a new congestion avoidance phase starts.**

TCP congestion policy summary



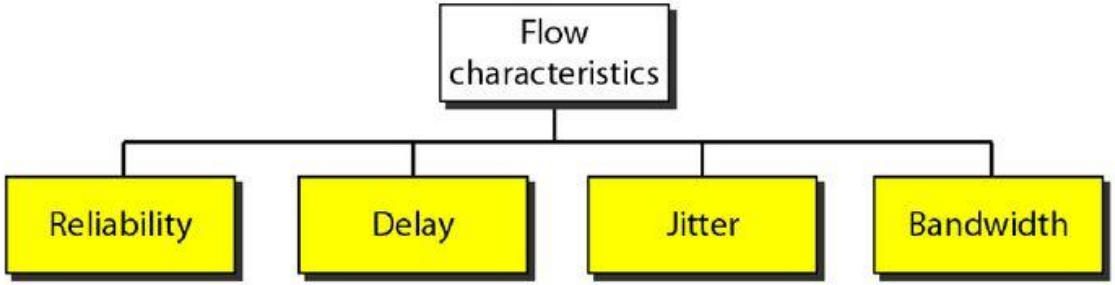
Congestion example



Quality of Service

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.

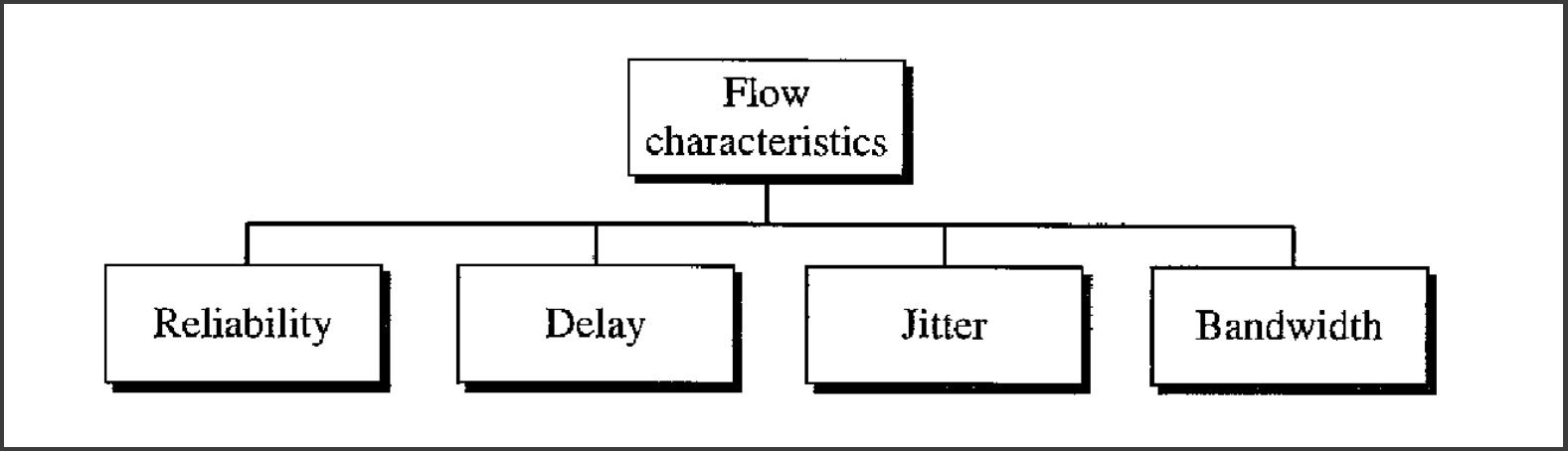


TECHNIQUES TO IMPROVE QoS

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.

Scheduling
Traffic Shaping
Resource Reservation
Admission Control

Flow Characteristics



Quality Of Service

Flow Characteristics

Reliability

Lack of Reliability means losing a packet or acknowledgement

Delay

Minimum Delay Required in

Video Conferencing or Audio Conferencing or Remote Login

Jitter

It is variation in delay for packets belonging to same flow

Packets		Delay		Delay	
P_1	0	20	20	21	21
P_2	1	21	20	23	22
P_3	2	22	20	21	19
P_4	3	23	20	28	25
		ST		RT	RT

Constant Delay
Low Jitter
Audio & Video

Variable Delay
High Jitter
Not acceptable for
Audio & Video

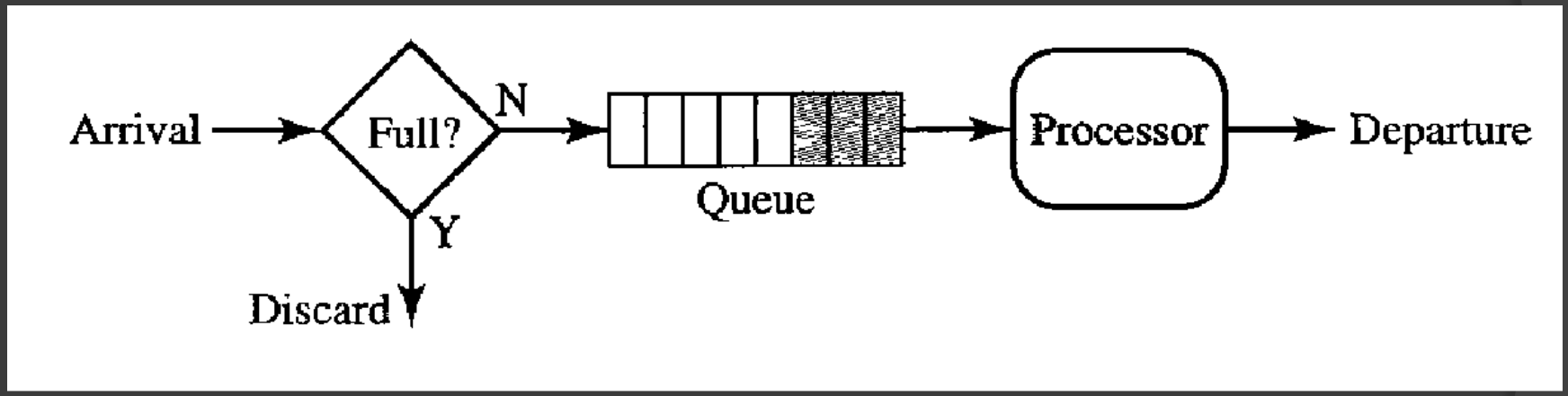
Bandwidth

High Bandwidth for Video Conferencing.
Low Bandwidth for E-Mail

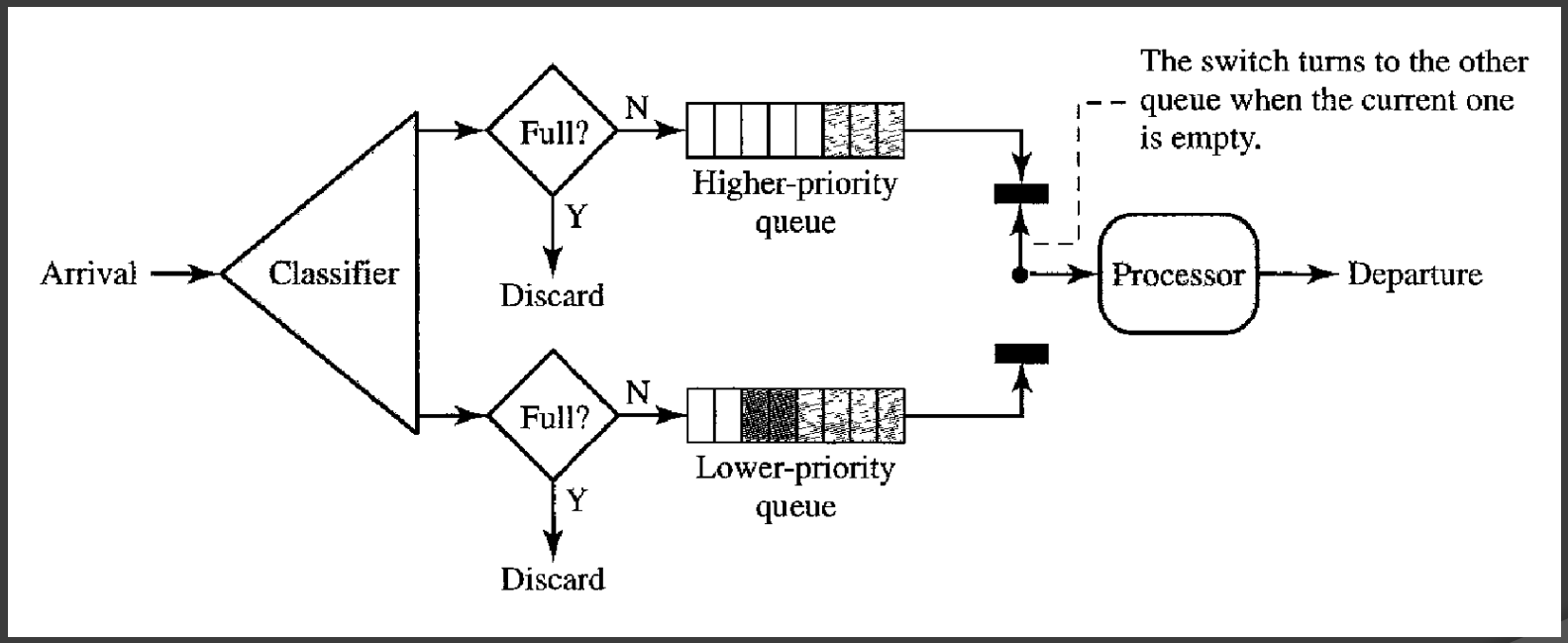
Techniques to improve QoS

- Scheduling
  - Treating all flows coming to router in fair manner
  - First-in-First-out Queuing
  - Priority Queuing
  - Weighted Fair Queuing

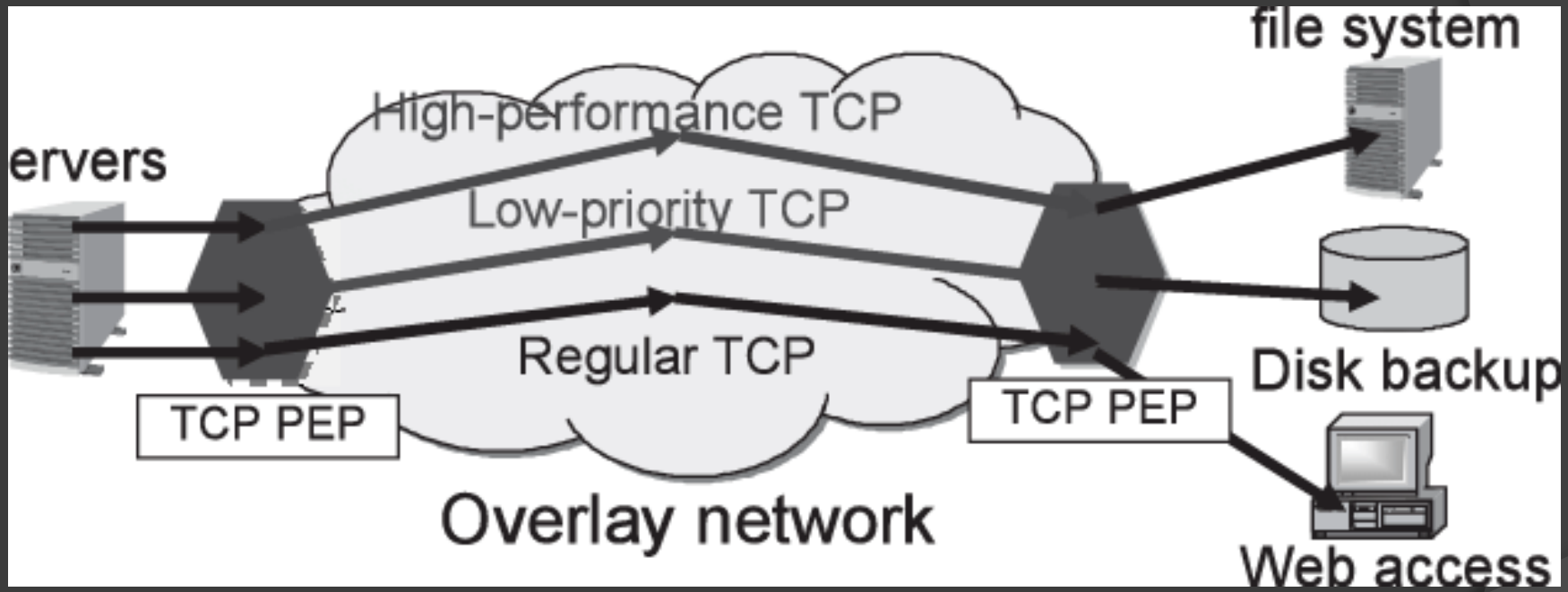
FIFO Queue



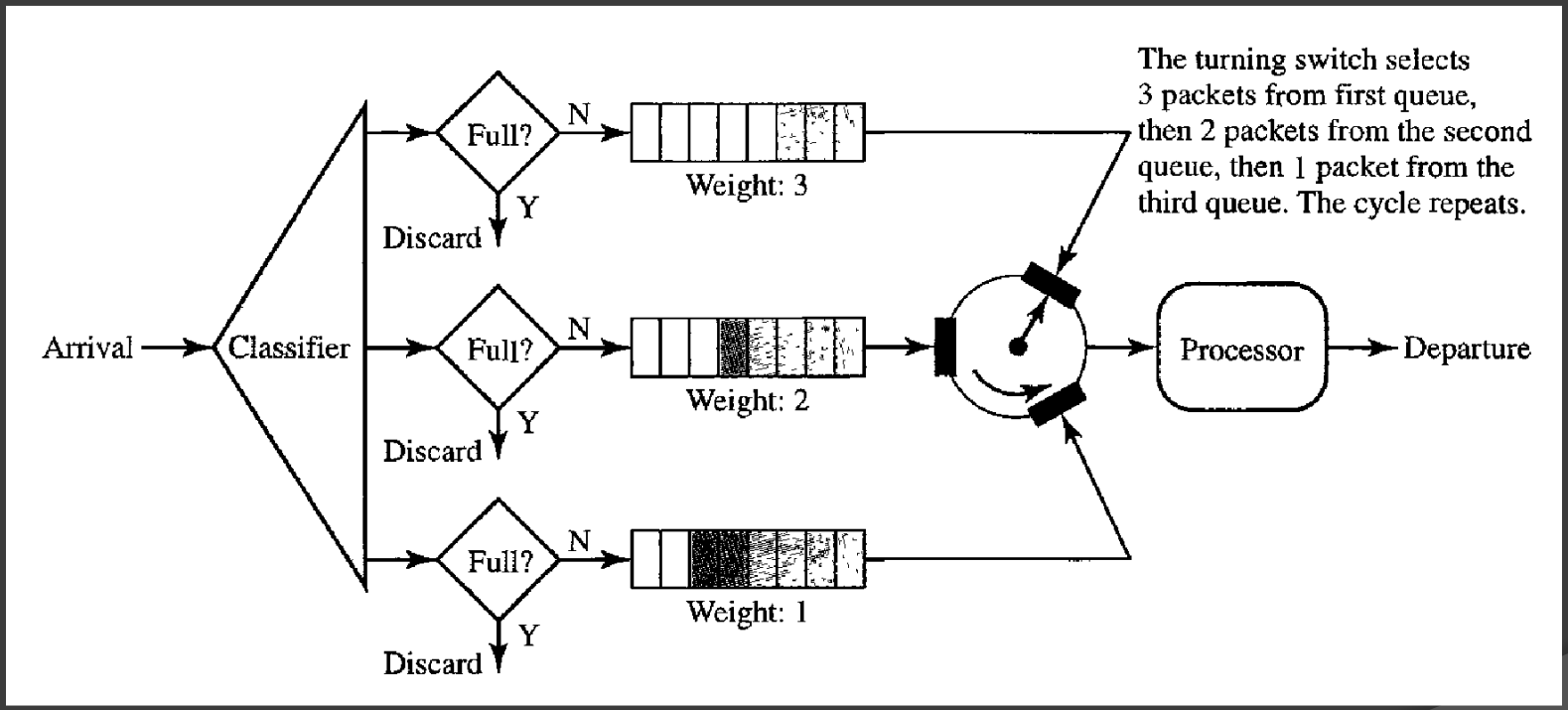
Priority Queue



Drawback:'Starvation'


file system
High-performance TCP
ervers
Low-priority TCP
Regular TCP
Disk backup
TCP PEP
TCP PEP
Overlay network
Web access

Weighted Fair Queue

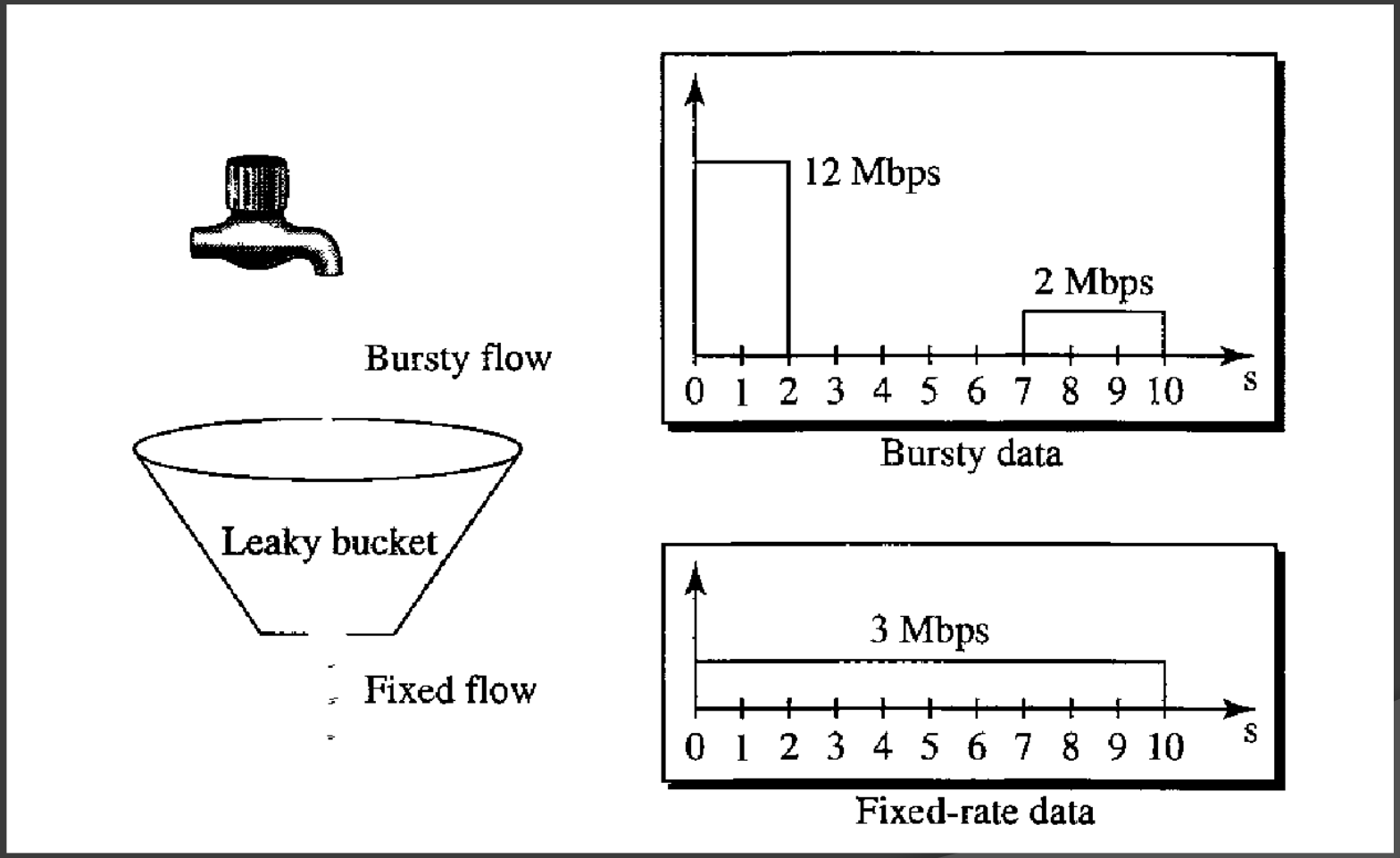


Traffic Shaping

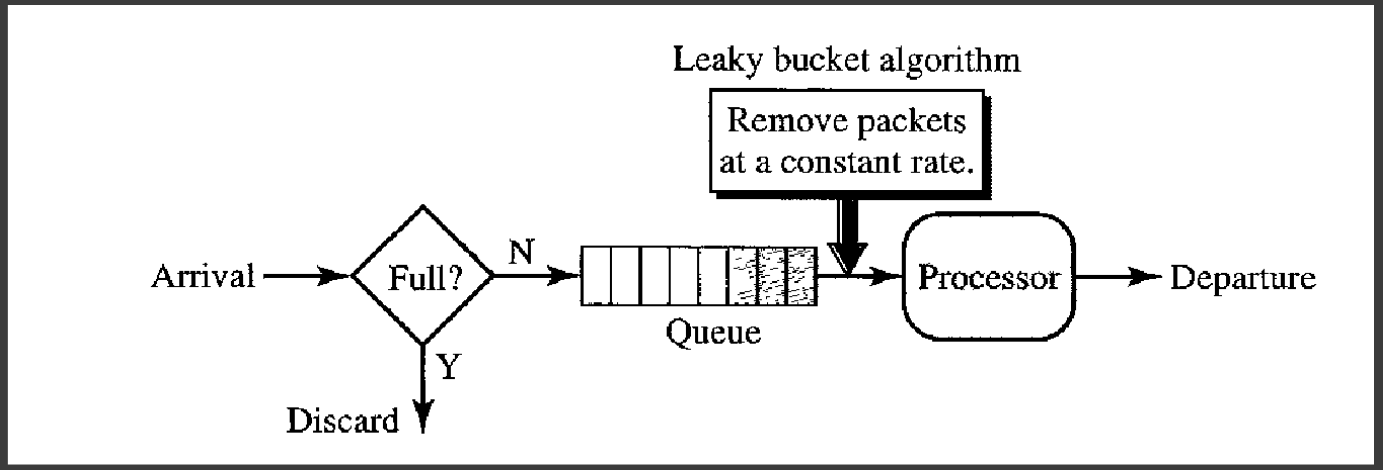
- It is a mechanism used to control the amount and rate of traffic sent to network.

- Two techniques:
- 1)Leaky bucket.
- 2)Token bucket.

Leaky Bucket

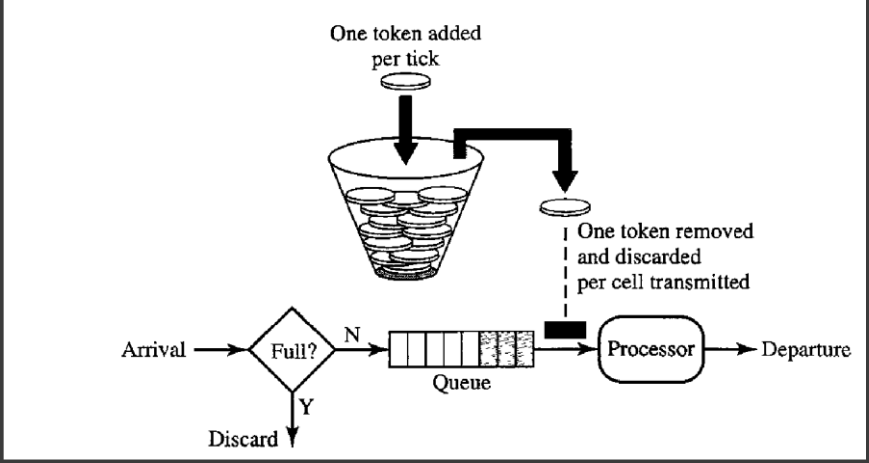


Leaky Bucket Implementation

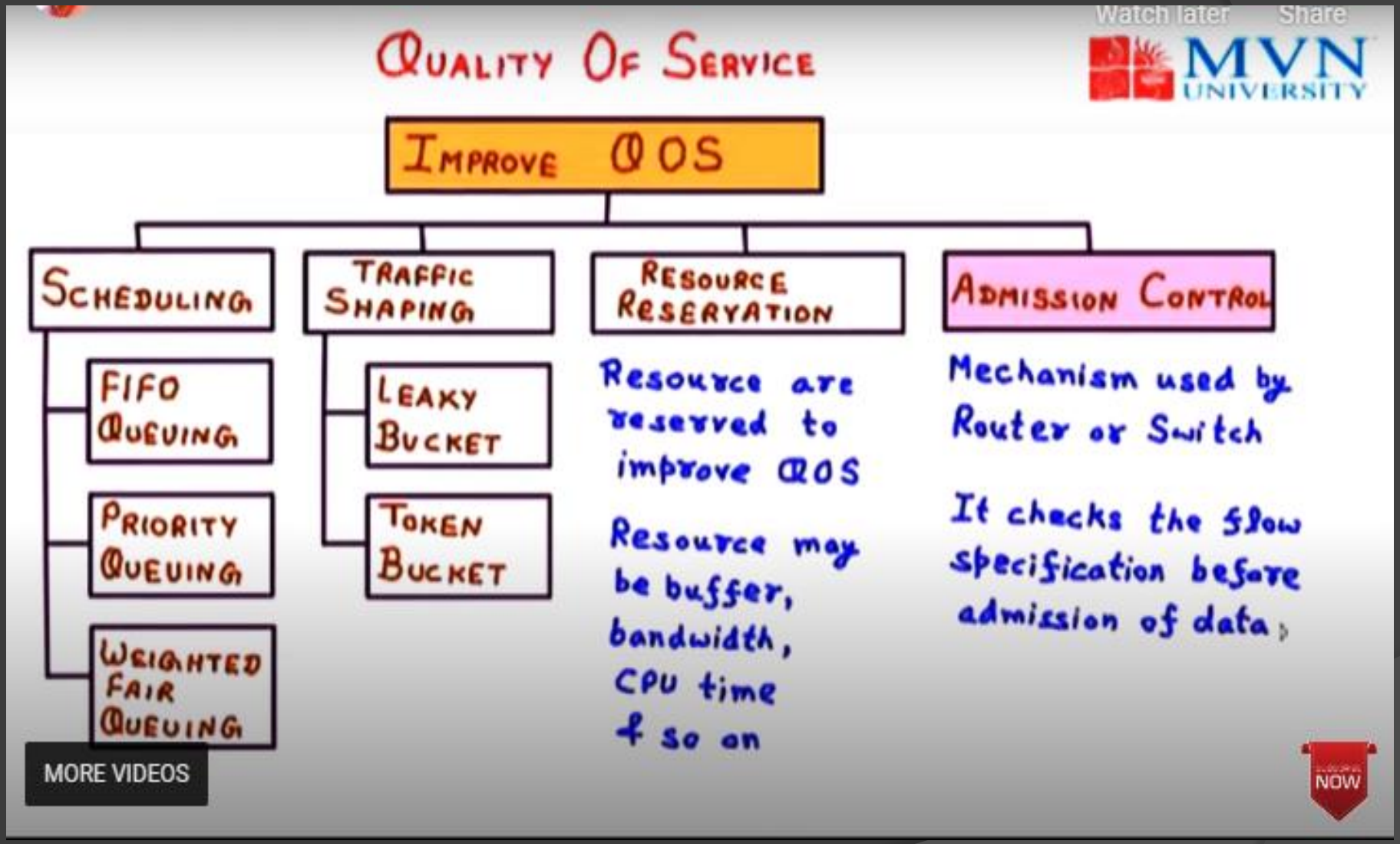


- This mechanism shapes bursty traffic to fixed rate traffic,thus improving QoS.
- However,if ‘bucket’ is full,packets are dropped.

Token Bucket



- Bursty traffic into regulated maximum rate.
- Accountability for the free time of source as well.
- Efficient utilisation of empty bandwidth.


Watch later
Share
QUALITY OF SERVICE
MVN UNIVERSITY
IMPROVE QOS
SCHEDULING
FIFO QUEUING
PRIORITY QUEUING
WEIGHTED FAIR QUEUING
TRAFFIC SHAPING
LEAKY BUCKET
TOKEN BUCKET
RESOURCE RESERVATION
Resource are reserved to improve QOS
Resource may be buffer, bandwidth, CPU time & so on
ADMISSION CONTROL
Mechanism used by Router or Switch
It checks the flow specification before admission of data
MORE VIDEOS
NOW

Quality of Service

- For many years, packet-switched networks have offered the promise of supporting multimedia applications, that is, those that combine audio, video, and data.
- After all, once digitized, audio and video information become like any other form of data—a stream of bits to be transmitted. One obstacle to the fulfillment of this promise has been the need for higher-bandwidth links.
- Recently, however, improvements in coding have reduced the bandwidth needs of audio and video applications, while at the same time link speeds have increased.

Quality of Service

- There is more to transmitting audio and video over a network than just providing sufficient bandwidth, however.
- Participants in a telephone conversation, for example, expect to be able to converse in such a way that one person can respond to something said by the other and be heard almost immediately.
- Thus, the timeliness of delivery can be very important. We refer to applications that are sensitive to the timeliness of data as *real-time applications.*

Quality of Service

- Voice and video applications tend to be the canonical examples, but there are others such as industrial control—you would like a command sent to a robot arm to reach it before the arm crashes into something.
- Even file transfer applications can have timeliness constraints, such as a requirement that a database update complete overnight before the business that needs the data resumes on the next day.

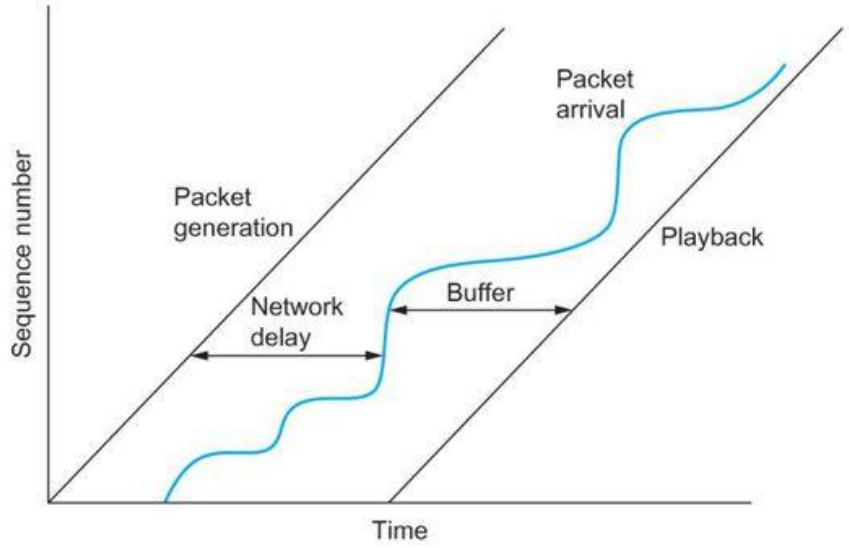
Application Requirements

Quality of Service

- The distinguishing characteristic of real-time applications is that they need some sort of assurance *from the network that data is likely to arrive on time (for some definition* of "on time").
- Whereas a non-real-time application can use an end-to-end retransmission strategy to make sure that data arrives *correctly, such a strategy cannot provide* timeliness.
- This implies that the network will treat some packets differently from others—something that is not done in the best-effort model.
- A network that can provide these different levels of service is often said to support quality of service (QoS).

Quality of Service

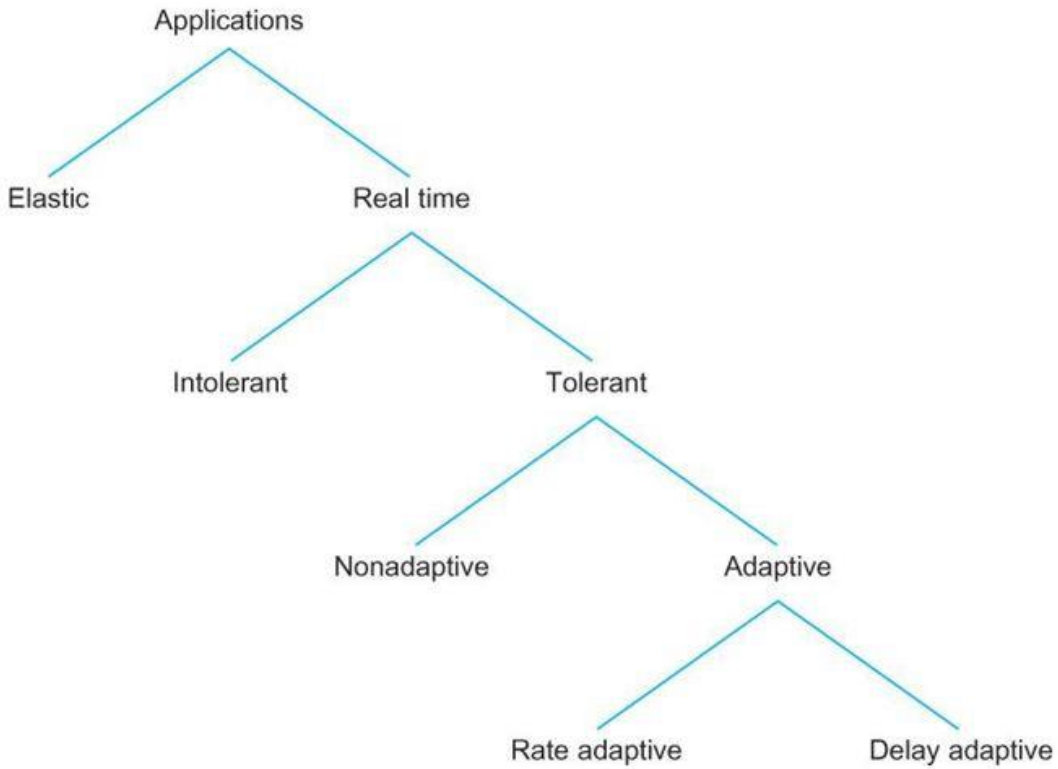
- Real-Time Applications



A playback buffer

Quality of Service

- Taxonomy of Real-Time Applications



Quality of Service

- Approaches to QoS Support
  - *fine-grained approaches, which provide QoS to individual applications or flows*
  - *coarse-grained approaches, which provide QoS to large classes of data or aggregated* traffic

  - In the first category we find "Integrated Services," a QoS architecture developed in the IETF and often associated with RSVP (Resource Reservation Protocol).
  - In the second category lies "Differentiated Services," which is probably the most widely deployed QoS mechanism.

Quality of Service

- Integrated Services (RSVP)
  - The term "Integrated Services" (often called IntServ for short) refers to a body of work that was produced by the IETF around 1995–97.
  - The IntServ working group developed specifications of a number of *service classes designed to meet the needs of some of the* application types described above.
  - It also defined how RSVP could be used to make reservations using these service classes.

Quality of Service

- Integrated Services (RSVP)
  - Service Classes
    - Guaranteed Service
      - The network should guarantee that the maximum delay that any packet will experience has some specified value
    - Controlled Load Service
      - The aim of the controlled load service is to emulate a lightly loaded network for those applications that request the service, even though the network as a whole may in fact be heavily loaded

Quality of Service

- Integrated Services (RSVP)
  - Overview of Mechanisms
    - Flowspec
      - With a best-effort service we can just tell the network where we want our packets to go and leave it at that, a real-time service involves telling the network something more about the type of service we require
      - The set of information that we provide to the network is referred to as a *flowspec.*
    - Admission Control
      - When we ask the network to provide us with a particular service, the network needs to decide if it can in fact provide that service. The process of deciding when to say no is called *admission control*.
    - Resource Reservation
      - We need a mechanism by which the users of the network and the components of the network itself exchange information such as requests for service, flowspecs, and admission control decisions. We refer to this process as *resource reservation*

Quality of Service

- Integrated Services (RSVP)
  - Overview of Mechanisms
    - Packet Scheduling
      - Finally, when flows and their requirements have been described, and admission control decisions have been made, the network switches and routers need to meet the requirements of the flows.
      - A key part of meeting these requirements is managing the way packets are queued and scheduled for transmission in the switches and routers.
      - This last mechanism is *packet scheduling.*

Quality of Service

- Integrated Services (RSVP)
  - Flowspec
    - There are two separable parts to the flowspec:
      - The part that describes the flow's traffic characteristics (called the *TSpec)* and
      - The part that describes the service requested from the network (the *RSpec).*
      - The RSpec is very service specific and relatively easy to describe.
      - For example, with a controlled load service, the RSpec is trivial: The application just requests controlled load service with no additional parameters.
      - With a guaranteed service, you could specify a delay target or bound.

Quality of Service

- Integrated Services (RSVP)
  - Flowspec
    - Tspec
      - We need to give the network enough information about the bandwidth used by the flow to allow intelligent admission control decisions to be made
      - For most applications, the bandwidth is not a single number
        - It varies constantly
      - A video application will generate more bits per second when the scene is changing rapidly than when it is still
        - Just knowing the long term average bandwidth is not enough

Quality of Service

- Integrated Services (RSVP)
  - Flowspec
    - Suppose 10 flows arrive at a switch on separate ports and they all leave on the same 10 Mbps link
    - If each flow is expected to send no more than 1 Mbps
      - No problem
    - If these are variable bit applications such as compressed video
      - They will occasionally send more than the average rate
    - If enough sources send more than average rates, then the total rate at which data arrives at the switch will be more than 10 Mbps
    - This excess data will be queued
    - The longer the condition persists, the longer the queue will get

Quality of Service

- Integrated Services (RSVP)
  - Flowspec
    - One way to describe the Bandwidth characteristics of sources is called a Token Bucket Filter
    - The filter is described by two parameters
      - A token rate *r*
      - A bucket depth *B*
    - To be able to send a byte, a token is needed
    - To send a packet of length *n*, *n* tokens are needed
    - Initially there are no tokens
    - Tokens are accumulated at a rate of *r* per second
    - No more than *B* tokens can be accumulated

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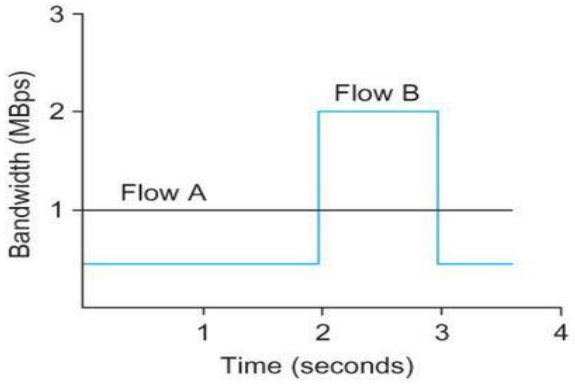
Quality of Service

- Integrated Services (RSVP)
  - Flowspec
    - We can send a burst of as many as *B* bytes into the network as fast as we want, but over significant long interval we cannot send more than *r* bytes per second
    - This information is important for admission control algorithm when it tries to find out whether it can accommodate new request for service

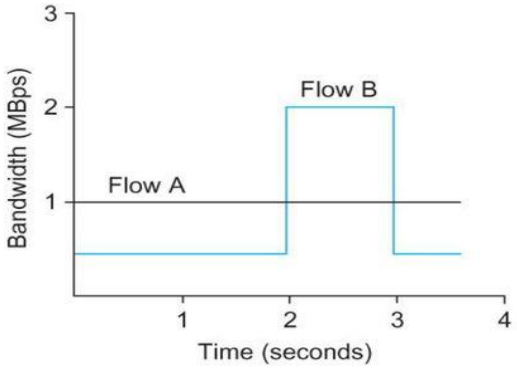
Quality of Service

- Flowspec
  - **The figure illustrates how a token bucket can be used to characterize a flow's Bandwidth requirement**
  - **For simplicity, we assume each flow can send data as individual bytes rather than as packets**
  - **Flow A generates data at a steady rate of 1 MBps**
    - **So it can be described by a token bucket filter with a rate $r = 1$ MBps and a bucket depth of 1 byte**
    - **This means that it receives tokens at a rate of 1 MBps but it cannot store more than 1 token, it spends them immediately**



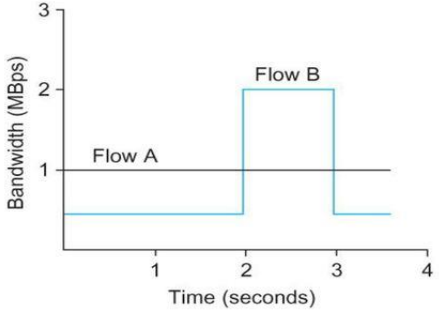
Quality of Service

- Flowspec
  - **Flow B sends at a rate that averages out to 1 MBps over the long term, but does so by sending at 0.5 MBps for 2 seconds and then at 2 MBps for 1 second**
  - **Since the token bucket rate *r* is a long term average rate, flow B can be described by a token bucket with a rate of 1 MBps**
  - **Unlike flow A, however flow B needs a bucket depth *B* of at least 1 MB, so that it can store up tokens while it sends at less than 1 MBps to be used when it sends at 2 MBps**



Quality of Service

- Flowspec
  - **For the first 2 seconds, it receives tokens at a rate of 1 MBps but spends them at only 0.5 MBps,**
    - **So it can save up 2 × 0.5 = 1 MB of tokens which it spends at the 3rd second**



Quality of Service

- Integrated Services (RSVP)
  - Admission Control
    - The idea behind admission control is simple: When some new flow wants to receive a particular level of service, admission control looks at the TSpec and RSpec of the flow and tries to decide if the desired service can be provided to that amount of traffic, given the currently available resources, without causing any previously admitted flow to receive worse service than it had requested. If it can provide the service, the flow is admitted; if not, then it is denied.

Quality of Service

- Integrated Services (RSVP)
  - Reservation Protocol
    - While connection-oriented networks have always needed some sort of setup protocol to establish the necessary virtual circuit state in the switches, connectionless networks like the Internet have had no such protocols.
    - However we need to provide a lot more information to our network when we want a real-time service from it.
    - While there have been a number of setup protocols proposed for the Internet, the one on which most current attention is focused is called Resource Reservation Protocol (RSVP).

Quality of Service

- Integrated Services (RSVP)
  - Reservation Protocol
    - One of the key assumptions underlying RSVP is that it should not detract from the robustness that we find in today's connectionless networks.
    - Because connectionless networks rely on little or no state being stored in the network itself, it is possible for routers to crash and reboot and for links to go up and down while end-to-end connectivity is still maintained.
    - RSVP tries to maintain this robustness by using the idea of *soft state in the routers.*

Quality of Service

- Integrated Services (RSVP)
  - Reservation Protocol
    - Another important characteristic of RSVP is that it aims to support multicast flows just as effectively as unicast flows
    - Initially, consider the case of one sender and one receiver trying to get a reservation for traffic flowing between them.
    - There are two things that need to happen before a receiver can make the reservation.

Quality of Service

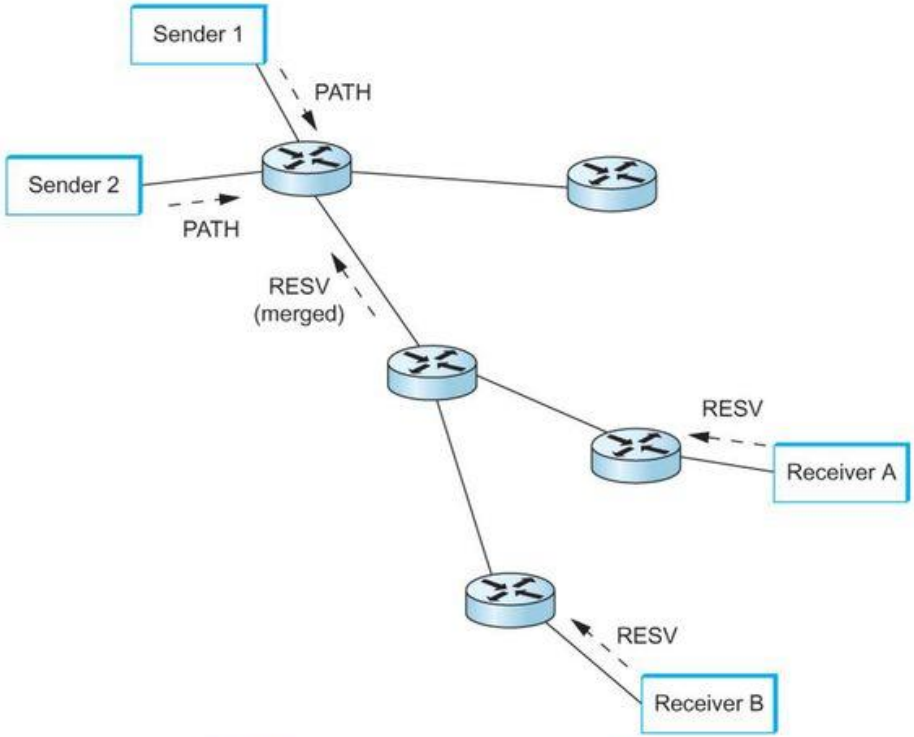
- Integrated Services (RSVP)
  - Reservation Protocol
    - First, the receiver needs to know what traffic the sender is likely to send so that it can make an appropriate reservation. That is, it needs to know the sender's TSpec.
    - Second, it needs to know what path the packets will follow from sender to receiver, so that it can establish a resource reservation at each router on the path. Both of these requirements can be met by sending a message from the sender to the receiver that contains the TSpec.
    - Obviously, this gets the TSpec to the receiver. The other thing that happens is that each router looks at this message (called a PATH message) as it goes past, and it figures out the *reverse path that will be used to send* reservations from the receiver back to the sender in an effort to get the reservation to each router on the path.

Quality of Service

- Integrated Services (RSVP)
  - Reservation Protocol
    - Having received a PATH message, the receiver sends a reservation back "up" the multicast tree in a RESV message.
    - This message contains the sender's TSpec and an RSpec describing the requirements of this receiver.
    - Each router on the path looks at the reservation request and tries to allocate the necessary resources to satisfy it. If the reservation can be made, the RESV request is passed on to the next router.
    - If not, an error message is returned to the receiver who made the request. If all goes well, the correct reservation is installed at every router between the sender and the receiver.
    - As long as the receiver wants to retain the reservation, it sends the same RESV message about once every 30 seconds.

Quality of Service

- Integrated Services (RSVP)
  - Reservation Protocol



Making reservations on a multicast tree

Quality of Service

- Integrated Services (RSVP)
  - Packet Classifying and Scheduling
    - Once we have described our traffic and our desired network service and have installed a suitable reservation at all the routers on the path, the only thing that remains is for the routers to actually deliver the requested service to the data packets. There are two things that need to be done:
      - Associate each packet with the appropriate reservation so that it can be handled correctly, a process known as *classifying packets.*
      - Manage the packets in the queues so that they receive the service that has been requested, a process known as packet *scheduling.*

Quality of Service

- Differentiated Services
  - Whereas the Integrated Services architecture allocates resources to individual flows, the Differentiated Services model (often called DiffServ for short) allocates resources to a small number of classes of traffic.
  - In fact, some proposed approaches to DiffServ simply divide traffic into two classes.

Quality of Service

- Differentiated Services
  - Suppose that we have decided to enhance the best-effort service model by adding just one new class, which we'll call "premium."
  - Clearly we will need some way to figure out which packets are premium and which are regular old best effort.
  - Rather than using a protocol like RSVP to tell all the routers that some flow is sending premium packets, it would be much easier if the packets could just identify themselves to the router when they arrive. This could obviously be done by using a bit in the packet header—if that bit is a 1, the packet is a premium packet; if it's a 0, the packet is best effort

Quality of Service

- Differentiated Services
  - With this in mind, there are two questions we need to address:
    - Who sets the premium bit, and under what circumstances?
    - What does a router do differently when it sees a packet with the bit set?

Quality of Service

- Differentiated Services
  - There are many possible answers to the first question, but a common approach is to set the bit at an administrative boundary.
  - For example, the router at the edge of an Internet service provider's network might set the bit for packets arriving on an interface that connects to a particular company's network.
  - The Internet service provider might do this because that company has paid for a higher level of service than best effort.

Quality of Service

- Differentiated Services
  - Assuming that packets have been marked in some way, what do the routers that encounter marked packets do with them?
  - Here again there are many answers. In fact, the IETF standardized a set of router behaviors to be applied to marked packets. These are called "per-hop behaviors" (PHBs), a term that indicates that they define the behavior of individual routers rather than end-to-end services

Quality of Service

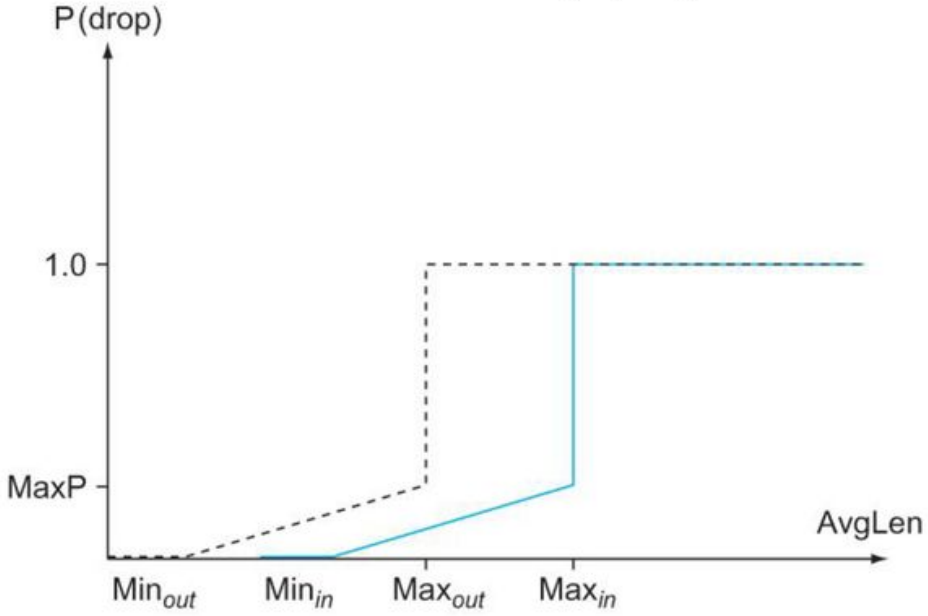
- Differentiated Services
  - The Expedited Forwarding (EF) PHB
    - One of the simplest PHBs to explain is known as "expedited forwarding" (EF). Packets marked for EF treatment should be forwarded by the router with minimal delay and loss.
    - The only way that a router can guarantee this to all EF packets is if the arrival rate of EF packets at the router is strictly limited to be less than the rate at which the router can forward EF packets.

Quality of Service

- Differentiated Services
  - The Assured Forwarding (AF) PHB
    - The "assured forwarding" (AF) PHB has its roots in an approach known as "RED with In and Out" (RIO) or "Weighted RED," both of which are enhancements to the basic RED algorithm.
    - For our two classes of traffic, we have two separate drop probability curves. RIO calls the two classes "in" and "out" for reasons that will become clear shortly.
    - Because the "out" curve has a lower MinThreshold than the "in" curve, it is clear that, under low levels of congestion, only packets marked "out" will be discarded by the RED algorithm. If the congestion becomes more serious, a higher percentage of "out" packets are dropped, and then if the average queue length exceeds Min_{in}, RED starts to drop "in" packets as well.

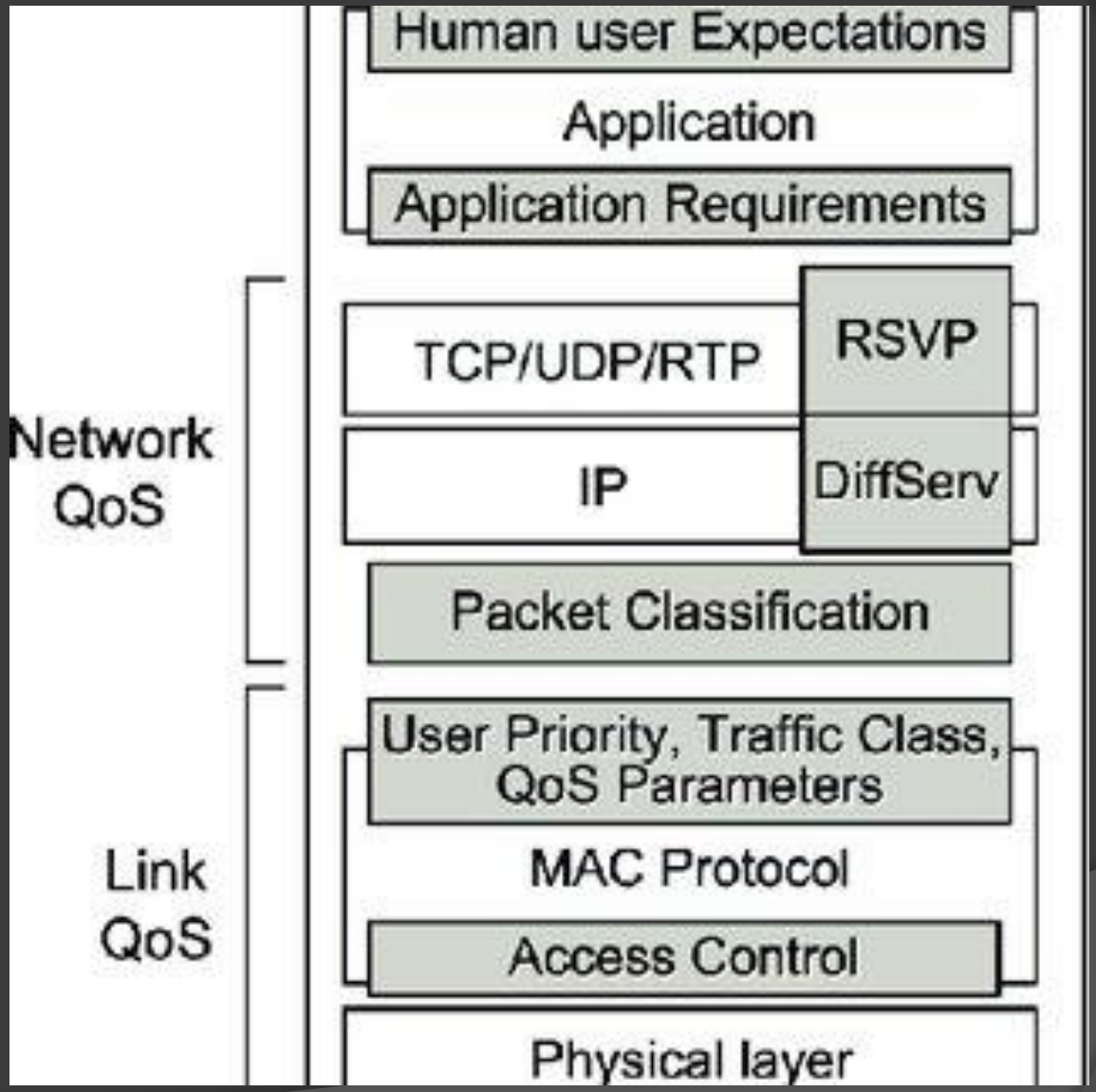
Quality of Service

- Differentiated Services
  - The Assured Forwarding (AF) PHB



RED with In and Out drop probabilities

QoS


Human user Expectations
Application
Application Requirements
TCP/UDP/RTP
RSVP
IP
DiffServ
Network QoS
Packet Classification
User Priority, Traffic Class, QoS Parameters
MAC Protocol
Access Control
Link QoS
Physical layer