

The background of the slide features a large, faint, circular seal of the Politecnico di Torino. The seal contains the text "POLITECNICO DI TORINO" at the top and "1859" and "1906" at the bottom. In the center of the seal is an illustration of a building with multiple towers and a central dome, surrounded by decorative elements.

# Multimedia Networking and Quality of Service

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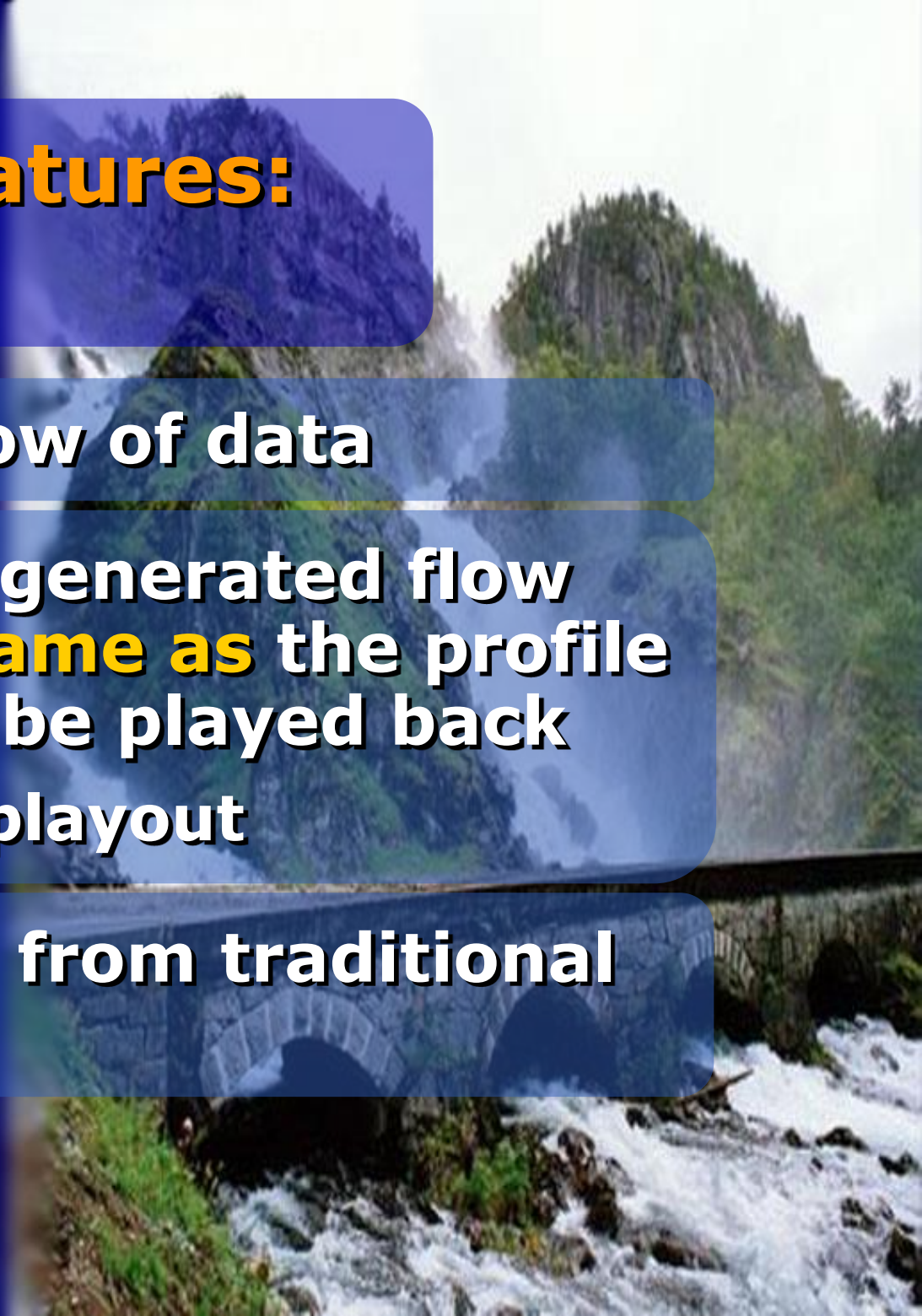
# **Networked Multimedia Applications**

**Maybe just one media, but ...**

**different features with  
respect to traditional  
applications**

# Distinctive Features: Streaming

- **Continuous** flow of data
- The profile of generated flow must be **the same as** the profile of the flow to be played back
  - Continuous playout
- Very different from traditional applications





# Distinctive Features: Interactivity

- With another human
- With a computer
- **Short** response time



# Distinctive Features

- **Large transmission bandwidth**
- **Group communications**
  - **Many to many communications**





# **Requirements on the network**

# Streaming 流

- Limited loss
  - Many applications tolerate loss to some extent

- Constant delays





# Interactivity

交互性

- **Low delay**
  - **Verbal interaction:**  
**below 100 ~ 150 ms one way**

QoS

*Quality of Service*

# Large Transmission Bandwidth

更大的传输带宽

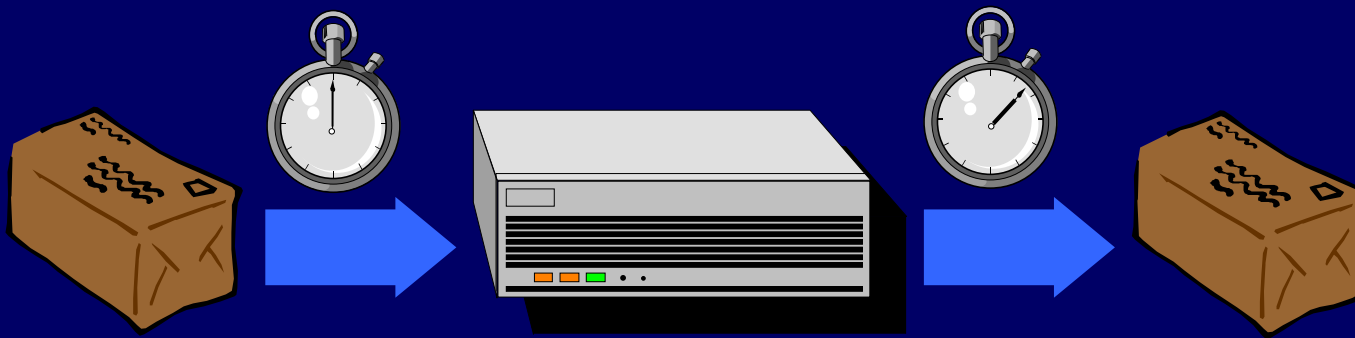
## High resource availability

- Transmission capacity
- Memory in network nodes (buffers)
- Processing power (routing, etc.)
- Switching

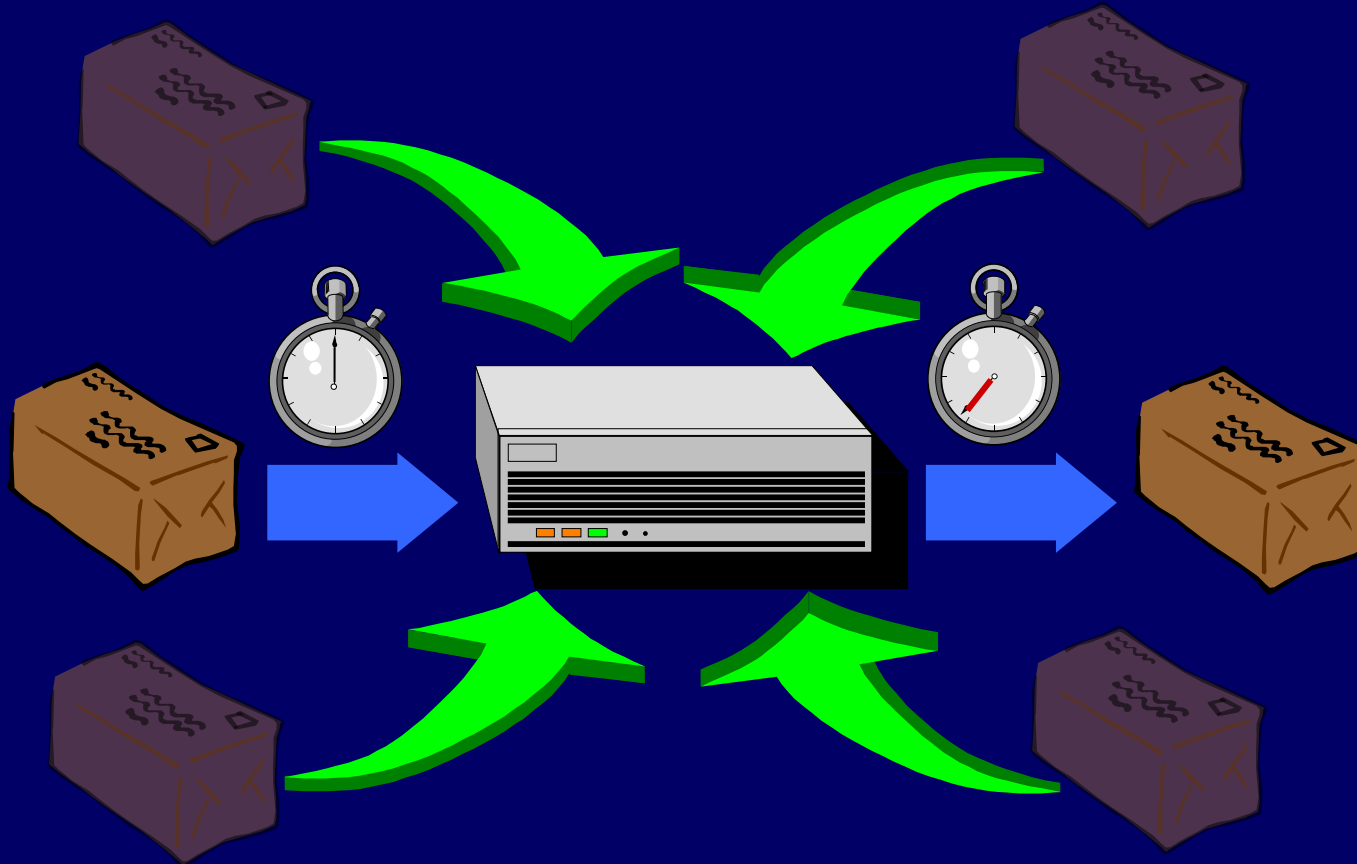
**Technology  
advances help**

# Delay: That's the Problem!!

Multimedia applications are  
also generally called  
*real-time* applications



# Delay: What's the Problem?



**It is different depending on  
the *instantaneous* load on  
network nodes**



# Countermeasures in the Network

→ Traffic classification

→ Sophisticated scheduling algorithms  
精细的  
→ WFQ, RR, WRR, CBQ

→ Control on traffic entering the network  
→ At various levels

→ (QoS routing)

# In other words

- **Limit the amount of packets arriving at network nodes**
- **Handle appropriately packets that need specific QoS**

# Control on Traffic

## → Packet level

→ Shaping/policing

## → Call/flow level

→ Signalling with resource reservation

→ RSVP

Resource reSerVation Protocol (IP)

→ UNI

User Network Interface (ATM)

# Control on Traffic

## → A priori

### → Network engineering

网络工程

→ Network dimensioning  
according to expected traffic

→ Limit on the number of users

用来限制用户数

### → Traffic engineering

→ Controlled distribution of  
traffic across the network

控制流量的转发



# Countermeasures in the Network

**Quality of Service**  
**support**



# **Tools for Quality of Service Support Classification**

# Classification 分类

标识哪些数据包应该被QoS

**Identifying packets to which  
quality is to be guaranteed**

**in other words**

**In which queue to store  
an incoming packet**

# Classification

分类基于IP头和TCP/UDP头中的信息

**Based on information contained in the IP and TCP/UDP headers (quintuplet)**

- ▶ **Destination IP address**
- ▶ **Source IP address**
- ▶ **Transport protocol**
- ▶ **Destination port**
- ▶ **Source port**



# **Classification**

**Complex algorithms**

**Hardware implementations**



**ASIC:  
Application Specific Integrated Circuit**



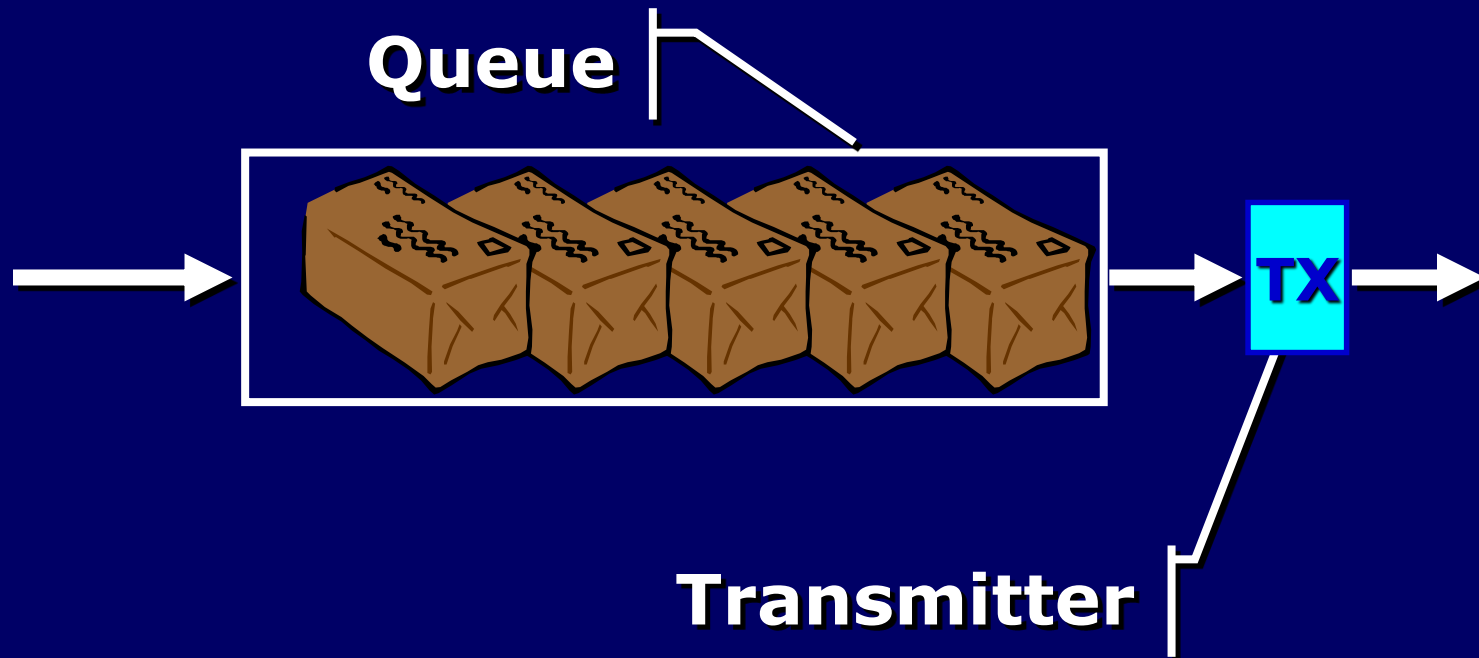
**CAM:  
Content Addressable Memory**



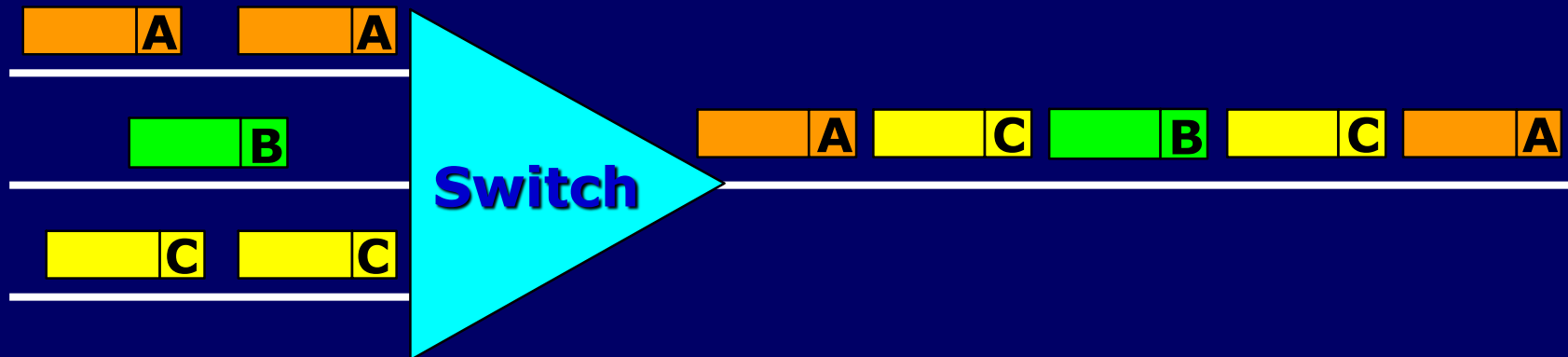
# Tools for Quality of Service Support Packet scheduling

包调度

# Simple Queuing FIFO (First In First Out)



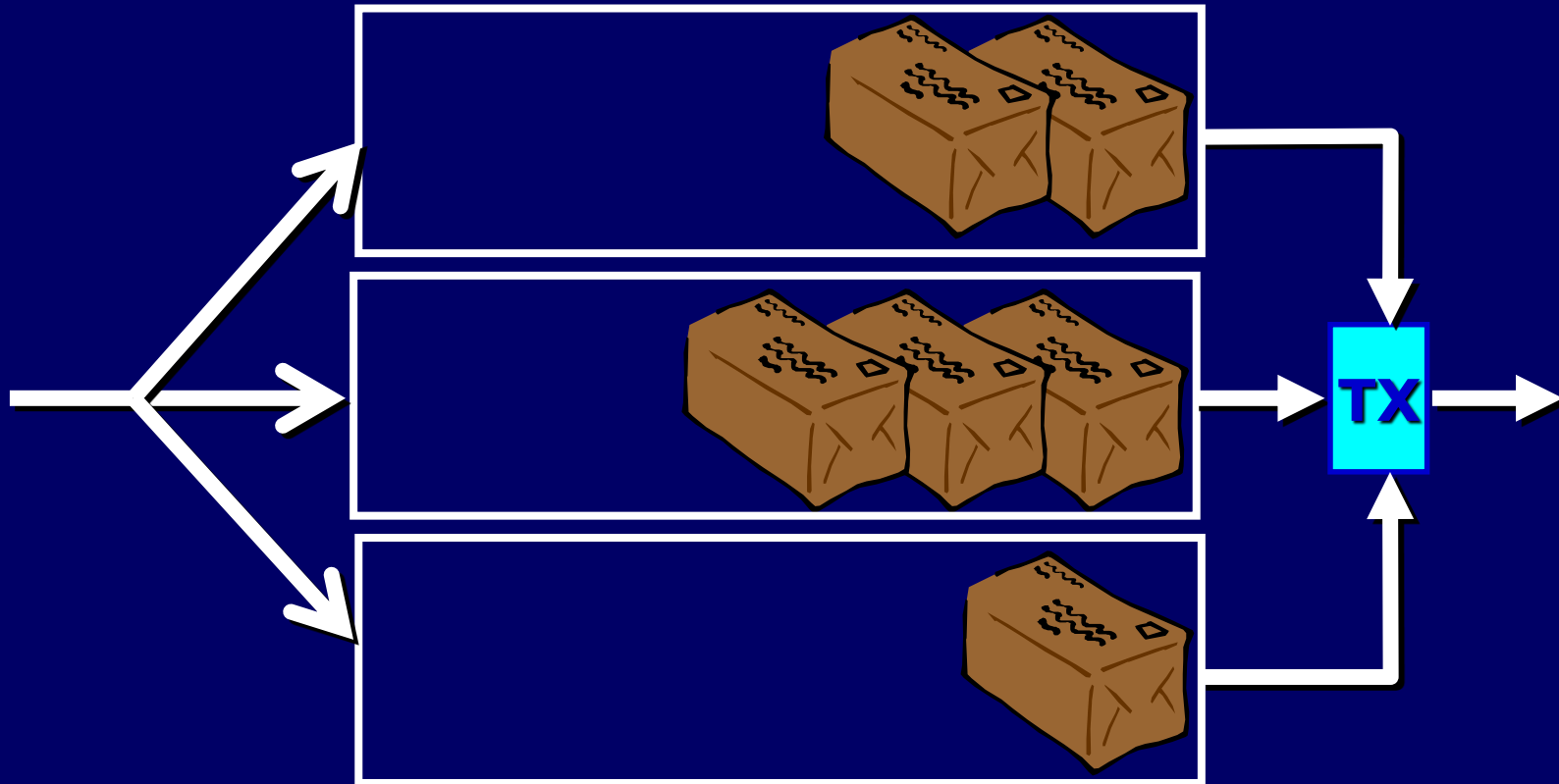
# Statistical Multiplexing



**Someone will not be satisfied**



# Multiple Queues and Scheduling



# Scheduling Algorithms

→ **Priority Queuing**

优先级

→ **Round Robin**

→ **Weighted Round Robin**

→ **Class Based Queuing (CBQ)**

按照类调度

→ **Weighted Fair Queuing (WFQ)**

按权重调度

→ **Deadline queuing**

按紧急程度

→ **Jitter Earliest Due Date  
(non work-conserving)**

# Queuing and Switching

## *Output queuing*

**The “simplest” solution**

**but ...**

**Switching capacity is a  
limited resource**

**There is no guarantee for packets  
to be switched as they arrive**

# Switching Capacity

- **Guaranteed immediate switching requires speed-up**
  - **The transfer speed of the switching fabric is higher than the input link speed**
- **Particularly critical when operating with high capacity links**

# Queuing and Switching

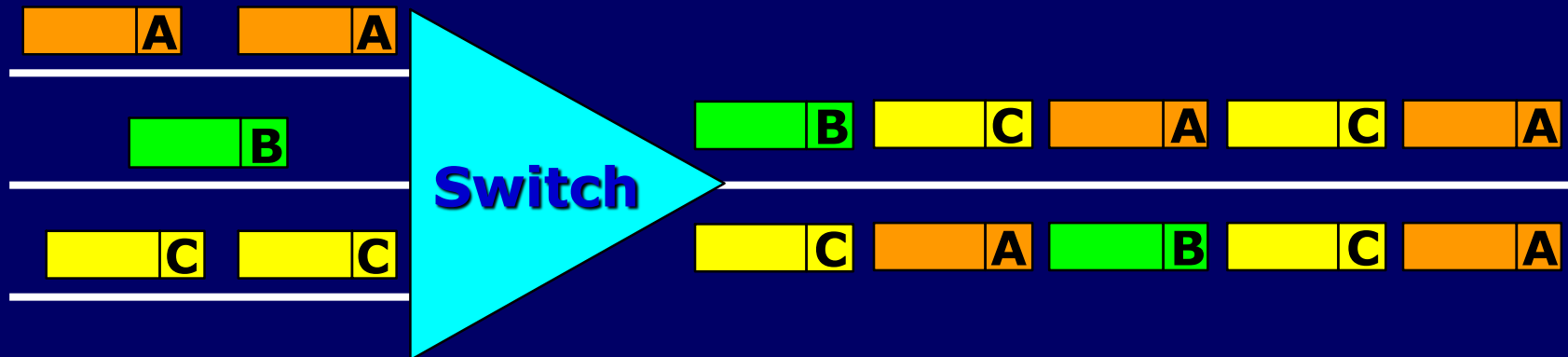
*Input queuing*

**Distributed control (complex)**

**Virtual output queuing**

**Queues inside the  
switching fabric  
(*distributed queuing*)**

# Are We Set?



**It is not possible to satisfy everyone!**



# **Tools for Quality of Service Support Control on Traffic**

控制流量

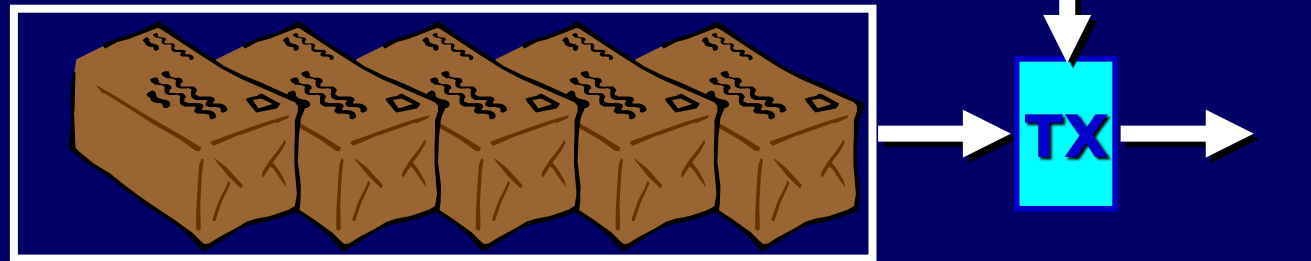


# Policing and shaping

Make sure that traffic entering the network has the expected profile

**Leaky Bucket**

Token bucket



# Leaky bucket

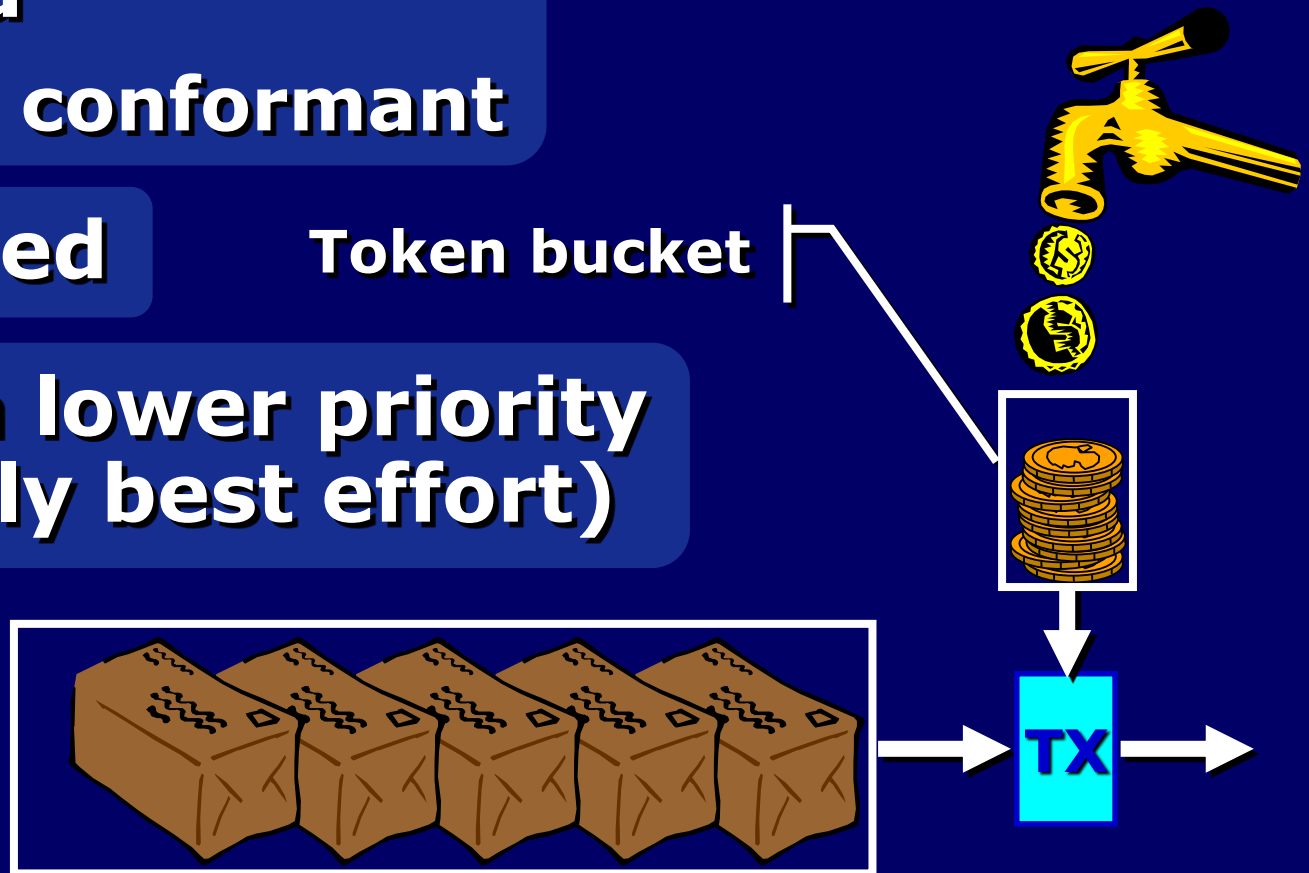
**Non conformant packets are**

→ **Delayed**  
→ **Made conformant**

→ **Discarded**

→ **Set at a lower priority  
(possibly best effort)**

Token bucket



# **Call Admission Control (CAC)**

## **→ Signalling**

- Description of generated traffic**
- Description of required service**
- Examples: RSVP e UNI ATM**

## **→ Resource Reservation**

# QoS routing

- **Finding a route with required resources**
- **Routing protocols distribute in real-time information on resource availability**
  - **Very dynamic information**

# QoS routing

- **Routing decisions are based on resource availability information**
  - **Not only on topological information**
- **Instability with connectionless data transfer**
- **E.g., PNNI (private network node interface) in ATM**
  - **Cranckback**

# **Network engineering**

## **Traffic engineering**

### **Preventive actions**

- Network is dimensioned for the (almost) worst case**
  - Statistics on user traffic**
- Traffic matrix is determined**
  - Traffic distribution**

# **Network engineering**

## **Traffic engineering**

### **Actions throughout**

- **Network state is continuously monitored**
- **Network dimensioning and traffic matrix can be changed if needed**



# Network engineering

## Traffic engineering

### Distinctive properties



**Low efficiency in network resource utilization**



**Simplicity and scalability**

# **Internet Quality of Service Support Frameworks**

## **IntServ and DiffServ**

# Internet's Ambitious Solution: Integrated Services (IntServ)

## Features

- **Per-flow resource reservation** 按照流来保留资源
  - **RSVP: Resource reSerVation Protocol**
- **Guaranteed quality of service** QoS
  - **Per-flow queuing inside routers**

# Internet's Ambitious Solution: Integrated Services (IntServ)

## Limits

→ **High complexity**



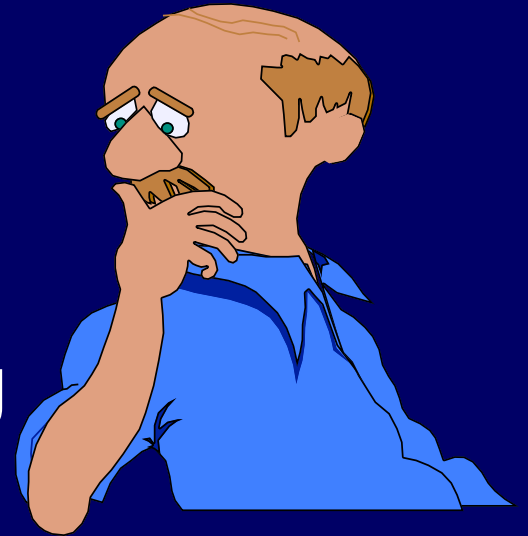
→ **Low scalability**



# Internet's Ambitious Solution: Integrated Services (IntServ)

## State of the art

- **Standard completed**
- **Implemented by router vendors**
  - **RSVP message handling**
  - **Queuing algorithms (?)**
- **Unusable on a large scale (public networks)**



# Lowering Ambitions: Differentiated Services (DiffServ)

- No quality of service guarantees
- No resource reservation
- Different service to different types (class) of traffic: **class of service**
  - DS (DiffServ) field
  - Per-class queuing

COS

按类排队



# Lowering Ambitions: Differentiated Services (DiffServ)

## How

→ **Network engineering**

NE

→ **Traffic engineering**

TE

→ **Access control at the boundaries**

→ **Policing**

通过控制边界路由器

# Lowering Ambitions: Differentiated Services (DiffServ)

## Features

- **Low efficiency**  
→ Large fraction of traffic is best-effort



- **Simplicity and scalability**

简单，扩展性好



- **Increasingly used**  
→ IP telephony

网络电话

