Guaranteed
Architecture: should allow traffic guarantees

Predicted
Best effort
Motivate admission control
AQM strategy: FIFO+

Some applications require minimum level of network performance

Motivation
Online some loss
Need solutions or guaranteed bounds on delay
Performance improves with lower delay
Speakers expect media to be intelligible
Features that you can leverage

A Class of Real-Time Applications
Buffer packets until playback point
Early packet arrival ok
Features that you can leverage
Performance improves with lower delay
Need absolute or statistical bound on delay
Tolerate some loss

Rigid vs. Adaptive Applications
Two classes of applications
Rigid applications
Set fixed playback point (apriori bound)
Adaptive applications
Adapt playback point (de facto bound)

Rigid/approximate
Two classes of playback applications
Rigid applications
Set fixed playback point (apriori bound)
Adaptive applications
Adapt playback point (de facto bound)
A priori bound > de facto bound
The distinction here is whether the application would tolerate interruptions

Playback applications
Gamble that network conditions will be the same now as in the past

A Priori vs. De Facto
Two classes of applications
A priori bound > de facto bound
The distinction here is whether the application would tolerate interruptions

Some applications require minimum level of network performance

Key Ideas
Service interface: token bucket defining rate & burstiness
AVB parameters: TFS+ Mechanisms:
Multimedia admission control
Best effort
Guaranteed
Predicted
Guaranteed: should allow traffic guarantees

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Packet Networks
Integrated Services
CS551
Real-time Applications

Computer Communications - CSCI 551

Delay adaptive
Rate adaptive
Non-adaptive
Adaptive

Loss, delay tolerant
Intolerant

Characterization of source traffic
Service interface
Packet scheduling
Admission control
Policing

Architectural Components

Types of Network Service Commitments

Service Interface: Flowspecs
Rspec: describes the service requested from the network
Tspec: describes the flow's traffic characteristics

Operational:
- For intolerant and rigid applications:
  - Guaranteed service
- For tolerant and adaptive applications:
  - Predicted service

Token Bucket Filter

Token Bucket Operation

Token Bucket Filter

For intolerant and rigid applications:
- Guaranteed service

For tolerant and adaptive applications:
- Predicted service

Performance: (high seq delay bounds)

Types of Network Service Commitments

Token Bucket Filter

Types of Network Service Commitments

Operational:
- For intolerant and rigid applications:
  - Guaranteed service
- For tolerant and adaptive applications:
  - Predicted service

Two Components:
- Applications: How sensitive the applications are to the network
- Network: How sensitive the network is to the applications

Characterization of QoS network will deliver
Characterization of source traffic

Real-time Applications
In the long run, rate is limited to $r$.

Amount of traffic entering at interval $T$ is bounded by:

In the short run, a burst of size $B$ can be sent.

**Token Bucket Characteristics**

**Token Bucket Specs**

**Possible Token Bucket Uses**

**Guaranteed Proven by Parekh**

**Predicted Service**

**Scheduling Guaranteed Traffic**

**Guarantee Proven by Parekh**

**Predicted Service**

**Scheduling Guaranteed Traffic**

**Token Bucket Characteristics**
FIFO+ has characteristics similar to error diffusion in computer graphics.

Original pixel value is an intensity value between 0 (black) and 1 (white). Represent the picture in pure black and white through thresholding—e.g., replace value by 1 if intensity ≥ 0.5 and replace value by 0 if intensity < 0.5. Error diffusion—start with thresholding, carry error into the next pixel, and replace value.

Simulation shows:

- Predicted Service: FIFO+
- Admission control not addressed in this paper
- Best effort not an issue; no guarantee
- Overloading the network
- Why is this better? Will fail to satisfy guarantees if we predict and guarantee traffic can overload the network
- Predicted and guaranteed traffic can overload the network

Unified Scheduling

- Scheduling: use WFQ in routers
- Other traffic aggregates in separate queue
- Strict priority with FIFO+
- Best effort traffic gets lowest priority
- Guaranteed traffic

Guaranteed traffic

predictive traffic classes:

- Assume 3 types of traffic: guaranteed, predictive, best-effort
- Delay (sum of delays at each hop)

Admission Control

- Admission control not addressed in this paper
- Best effort traffic
- Guaranteed traffic
- Predicted traffic
- Predicted and guaranteed traffic can overload the network
- Admission control not addressed in this paper
- Do we need to change our network service model?
- Do we really need integrated services?
- Or, do we just let applications adapt, and engineer the network for enough bandwidth?
- How do we even study this question?
- But...

Predicted Service: FIFO+

- Error diffusion—carry error into the next pixel, and replace value.
- Thresholding—start with initial value, then subtract. For l magnitude < 0.5, replace value with
- Thresholding—e.g., replace value by
- Thresholding—e.g., replace value by
- Original pixel value is an intensity value,
- Error diffusion in computer graphics.
- FIFO+ characteristics similar to
But no commercial interest in the technology
Lots of work in the area (e.g., ATM, RSVP)

State of Integrated Services

Can we build these schedulers in hardware?

Lots of work in the area (e.g., ATM, RSVP)

We understand many of the problems

Too complex?

Need per-flow state for scheduling

Can we build these schedulers in hardware?

Can we do something simpler?