Quality of Service

Outline

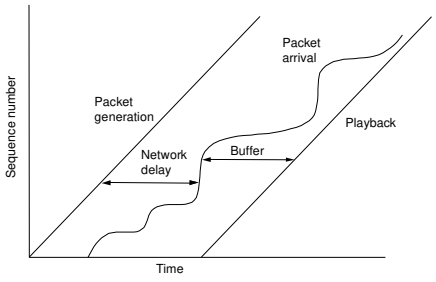
- Realtime Applications
- Integrated Services
- Differentiated Services

Realtime Applications

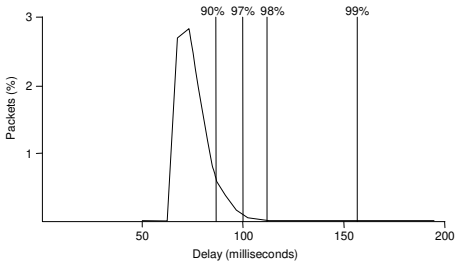
- Require "deliver on time" assurances
  - must come from *inside* the network

- Example application (audio)
  - sample voice once every 125us
  - each sample has a *playback time*
  - packets experience variable delay in network
  - add constant factor to playback time: *playback point*

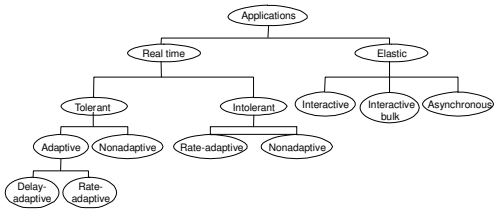
Playback Buffer



Example Distribution of Delays



Taxonomy



Integrated Services

- Service Classes
  - guaranteed
  - controlled-load
- Mechanisms
  - signalling protocol
  - admission control
  - policing
  - packet scheduling

Flowspec

- ***Rspec:*** describes service requested from network
  - controlled-load: none
  - guaranteed: delay target
- ***Tspec:*** describes flow's traffic characteristics
  - average bandwidth + burstiness: *token bucket* filter
  - token rate *r*
  - bucket depth *B*
  - must have a token to send a byte
  - must have *n* tokens to send *n* bytes
  - start with no tokens
  - accumulate tokens at rate of *r* per second
  - can accumulate no more than *B* tokens

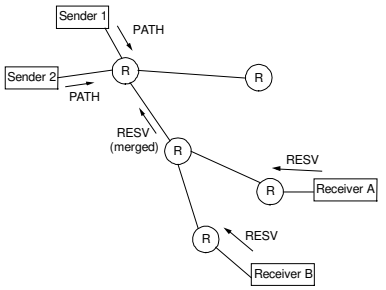
Per-Router Mechanisms

- Admission Control
  - decide if a new flow can be supported
  - answer depends on service class
  - not the same as *policing*
- Packet Processing
  - classification: associate each packet with the appropriate reservation
  - scheduling: manage queues so each packet receives the requested service

Reservation Protocol

- Called signaling in ATM
- Proposed Internet standard: RSVP
- Consistent with robustness of today's connectionless model
- Uses soft state (refresh periodically)
- Designed to support multicast
- Receiver-oriented
- Two messages: PATH and RESV
- Source transmits PATH messages every 30 seconds
- Destination responds with RESV message
- Merge requirements in case of multicast
- Can specify number of speakers

RSVP Example

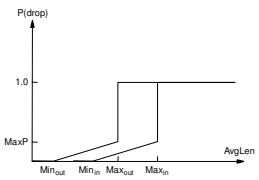


RSVP versus ATM (Q.2931)

- RSVP
  - receiver generates reservation
  - soft state (refresh/timeout)
  - separate from route establishment
  - QoS can change dynamically
  - receiver heterogeneity
- ATM
  - sender generates connection request
  - hard state (explicit delete)
  - concurrent with route establishment
  - QoS is static for life of connection
  - uniform QoS to all receivers

Differentiated Services

- Problem with IntServ: scalability
- Idea: segregate packets into a small number of classes
  - e.g., premium vs best-effort
- Packets marked according to class at edge of network
- Core routers implement some per-hop-behavior (PHB)
- Example: Expedited Forwarding (EF)
  - rate-limit EF packets at the edges
  - PHB implemented with class-based priority queues or WFQ

DiffServ (cont)

- Assured Forwarding (AF)
  - customers sign service agreements with ISPs
  - edge routers mark packets as being "in" or "out" of profile
  - core routers run RIO: RED with in/out