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

- Sequence number
- Packet generation
- Network delay
- Buffer
- Playback
- Packet arrival

Time

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Example Distribution of Delays
Taxonomy

- Applications
  - Real time
    - Tolerant
      - Adaptive
        - Delay-adaptive
      - Nonadaptive
      - Rate-adaptive
  - Intolerant
    - Rate-adaptive
      - Nonadaptive
  - Elastic
    - Interactive
      - Interactive bulk
    - Asynchronous
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 or shaping

• 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 Integrated Services
  – Scalability – amount of state in core routers
  – Classification cost in core routers
  – Limited service models (can’t say class A gets better service than class B, e.g.)

• Differentiated Services (DiffServ)
  – RFC 2474/2475
  – Goal is scalability
  – Flexible differentiation based on a set of components

• Key to the approach
  – *packet* classification and labelling at network *edge*
  – Forwarding “priority” according to label in the network core
    – per hop behavior
      • Core routers don’t have per-flow state
Example mechanism: RIO

- RED with In and Out
- Mechanism
  - packets: ‘in’ and ‘out’ bit
  - edge routers: tag packets
  - core routers: RIO
    (RED with In and Out)
Per-Hop Behaviors

• a description of the externally observable forwarding behavior of a DiffServ node applied to a particular DiffServ behavior aggregate (class)
  – Doesn’t define the implementation

• Example descriptions (generic)
  – Class A gets at least $x\%$ of link bandwidth
  – Class A receives priority over Class B
Expedited Forwarding PHB

• RFC 2598
• An EF class receives a guaranteed minimum bandwidth
  – Requires isolation from other traffic
  – Abstractly: we’ve created a virtual link with the required minimum bandwidth for the EF class
• Example mechanism for achieving: WFQ
Assured Forwarding PHB

- RFC 2597
- Traffic is divided into 4 classes each with 3 “drop-preference” categories.
- Each class receives a guaranteed minimum amount of bandwidth and buffering
- If you were an ISP how could make a product out of this kind of mechanism?
Core Stateless Fair Queuing

- DiffServ-like marking at the network edge
  - Packets in a flow are marked with their observed arrival rate (possibly weighted)
- Core routers
  - Preferentially drop packets with high arrival rates
  - Relabel packets according to their actual departure rate
- Relies on adaptation to packet loss by the sender to achieve fair allocations
  - But those who don’t play by the rules can be punished
Not playing by the rules – unfriendly flows

• Fire hose application
  – Gets $x\%$ of the available value from $x\%$ of the packets it sends
  – No motivation to reduce sending rate to match fair share
  – Network should punish this behavior by reducing packet delivery to below fair share

• Greedy AIMD
  – A bigger problem with FIFO/Tail Drop than with anything that approximates FQ
Quick Essay

• Consider the grading guide for project 2.
• Overall, was having the guide helpful, compared with your experience in project 1 and other projects you have done?
• What in the grading guide was most helpful to you in preparing project 2?
• What in the grading guide was least helpful to you in preparing project 2?
• What would you most like to see changed in the grading guide for project 3?