Today’s Lecture

- Project 3
  - In-Class Exercise
- Network Issues
  - Quality of Service

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

Example Distribution of Delays

Integrated Services

- Service Classes
  - guaranteed
  - controlled-load

- Mechanisms
  - resource reservation (signalling)
  - 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 signalling 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

- Associate packet with reservation (classifying):
  - source address, destination address, protocol number, source port, destination port
- Manage packets in queues (scheduling).

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

Coding

- Form into small groups
  - **Twist:** Must sit by people who you did not work with on the project

[Build a simple UDP chat server]
Write Threaded Code

• UDP Server
  – Step 1
    • Listen on port X (pass in via parameter)
    • Read message / display on screen
  – Step 2
    • Keep track of incoming IP / ports
    • Design
      – Local vs. global
      – struct vs. class

Write Main Function

• main function
  – Step 1
    • Start up the thread
    • Loop until input is QUIT!
  – Step 2
    • Send the typed text to all known other clients
  – Step 3
    • Allow adding of IP via syntax
      – ADDCLIENT 129.74.20.40 8908
  – Step 4
    • Dump current client list via DUMPSTATUS