

## Performance of Multimedia Delivery on the Internet Today

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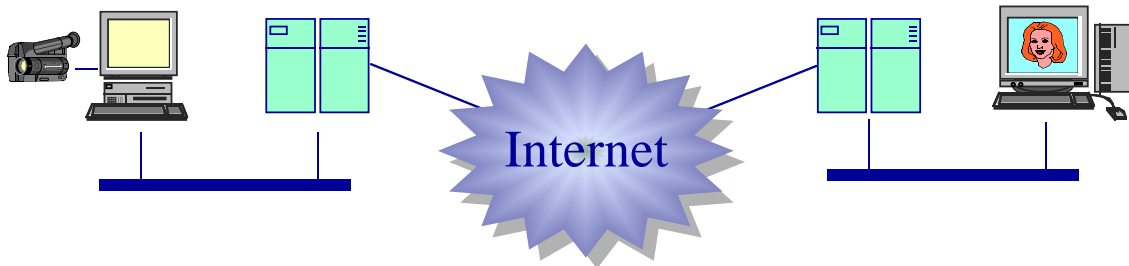
<http://www.cs.unc.edu/~jeffay/courses/comp249f99>

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## Performance on the Internet Today

### Outline

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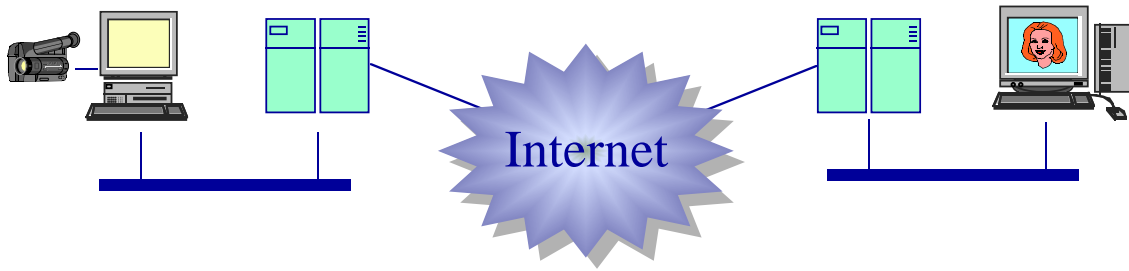


- ◆ A prototypical videoconferencing system
  - » Architecture
  - » Quality-of-service requirements
- ◆ Performance metrics
  - » Understanding end-to-end latency
- ◆ Some typical experimental results
- ◆ Conclusions?

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# Performance on the Internet Today

## Videoconferencing performance requirements

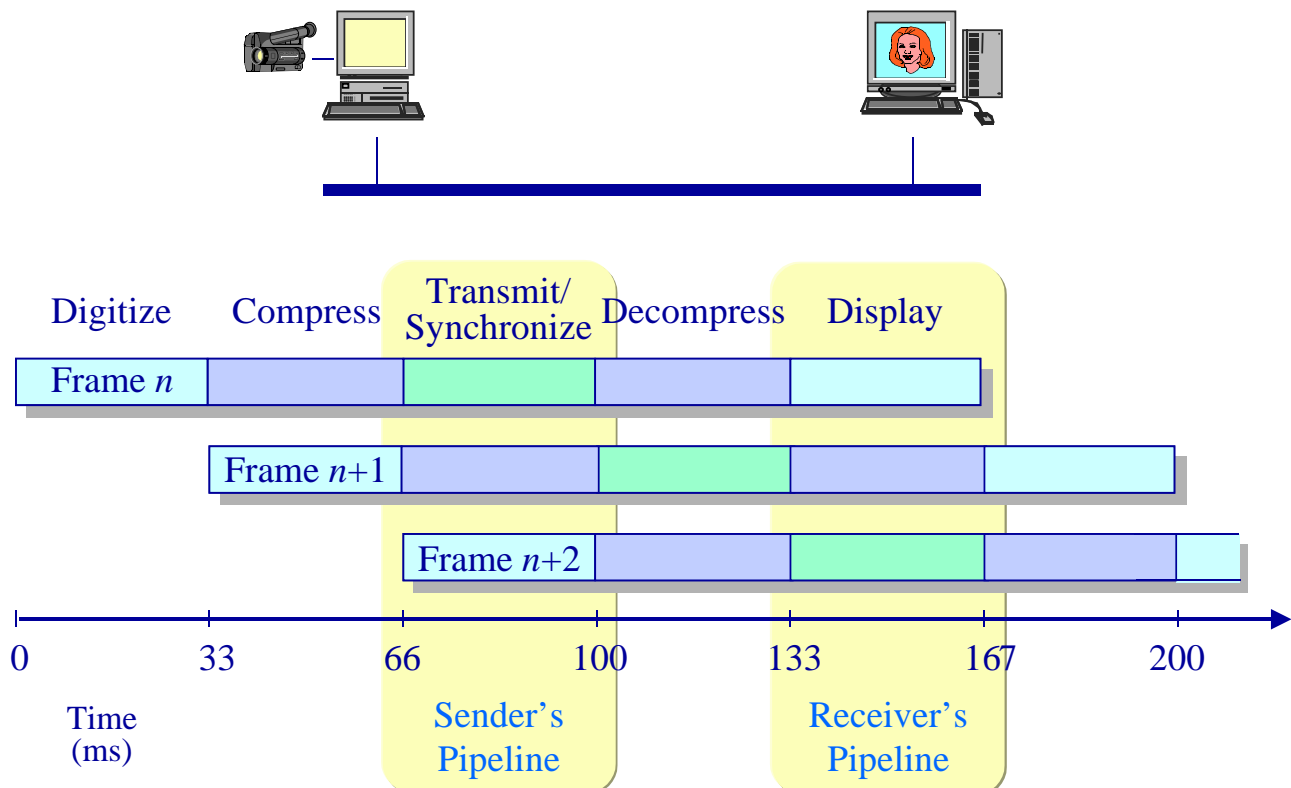


- ◆ No more than 250 ms end-to-end, one-way latency
- ◆ Continuous audio
- ◆ Minimum of 10 frames per second video throughput
- ◆ “Loosely synchronized” playout —  $\pm 80$  ms skew

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## Videoconferencing Performance Requirements

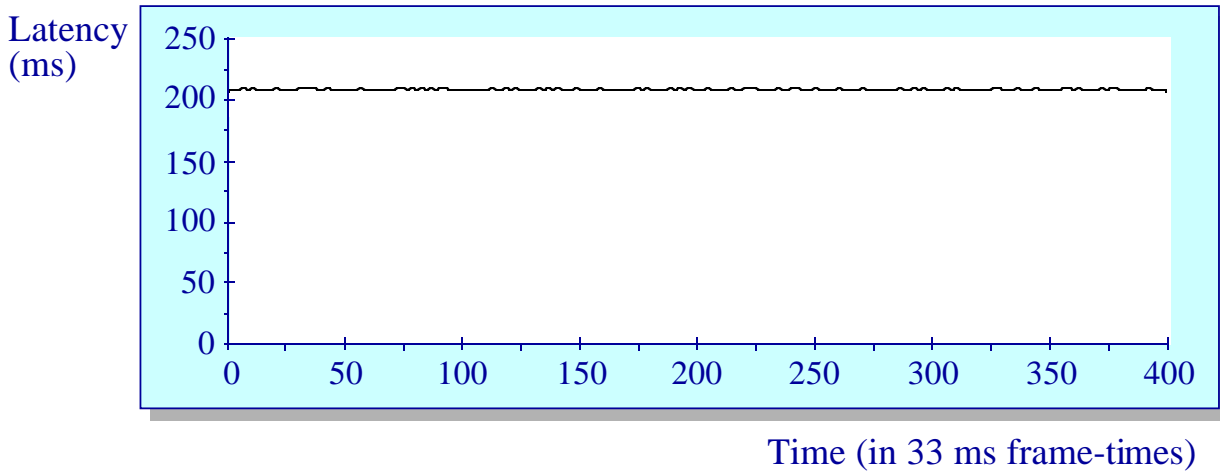
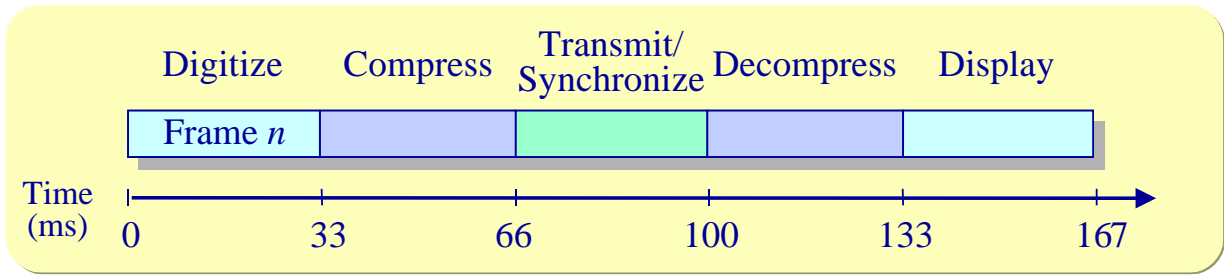
### Understanding end-to-end latency



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# Understanding End-to-End Latency

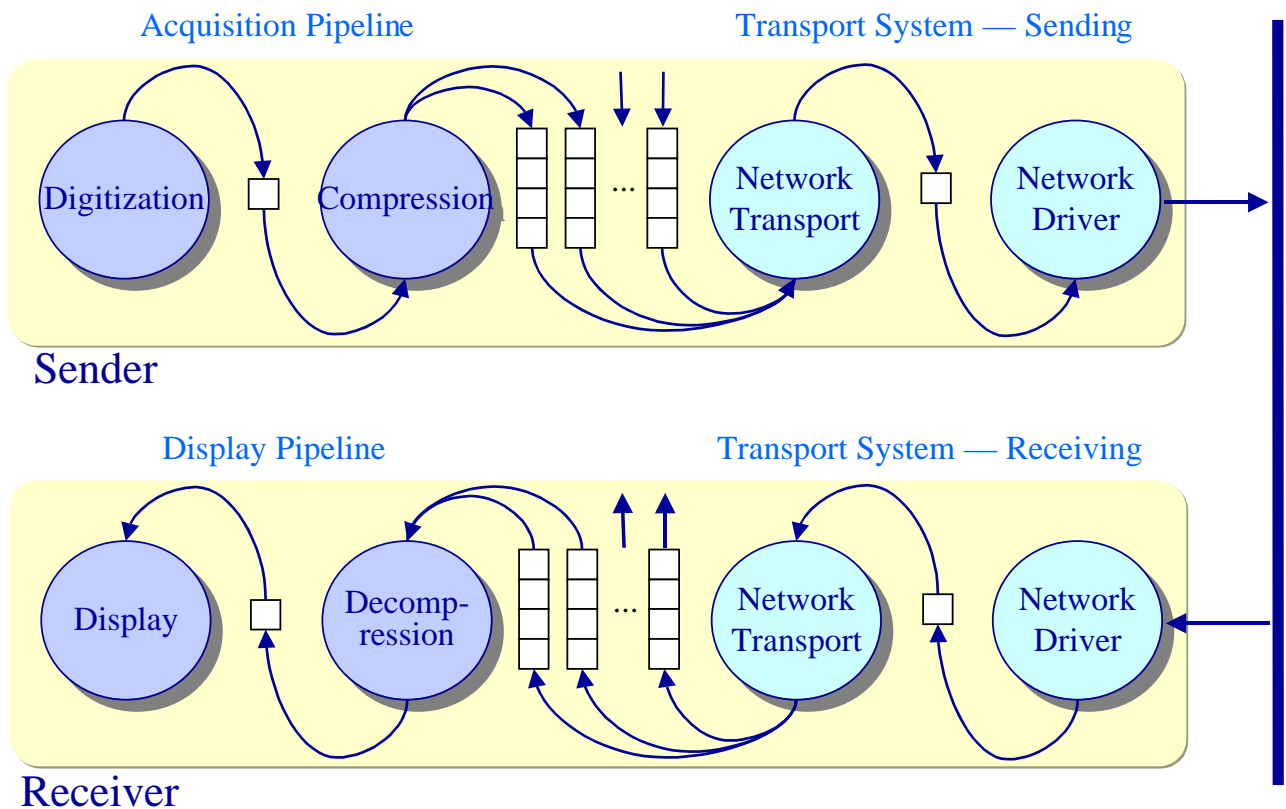
## Latency as a measure of continuity of playout



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# Understanding End-to-End Latency

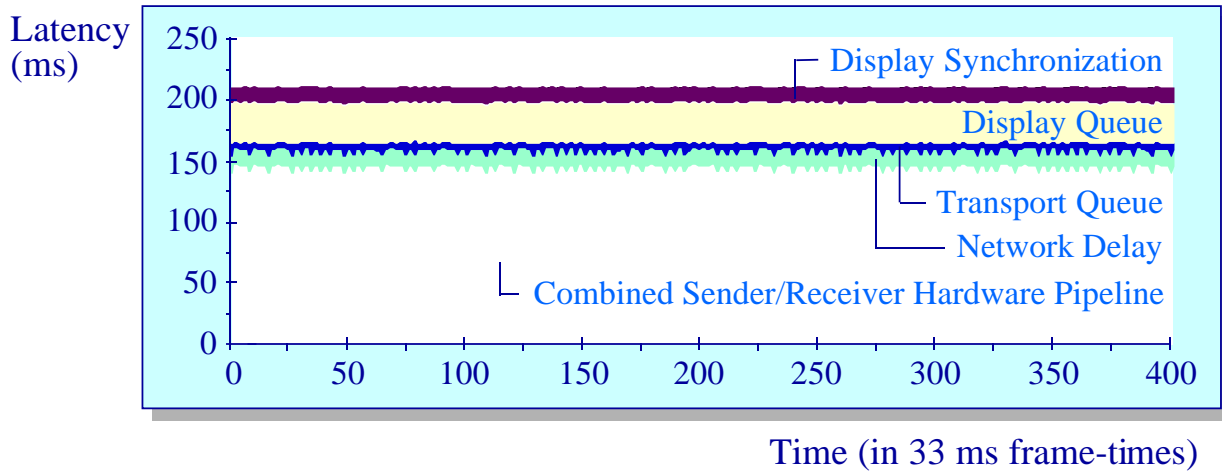
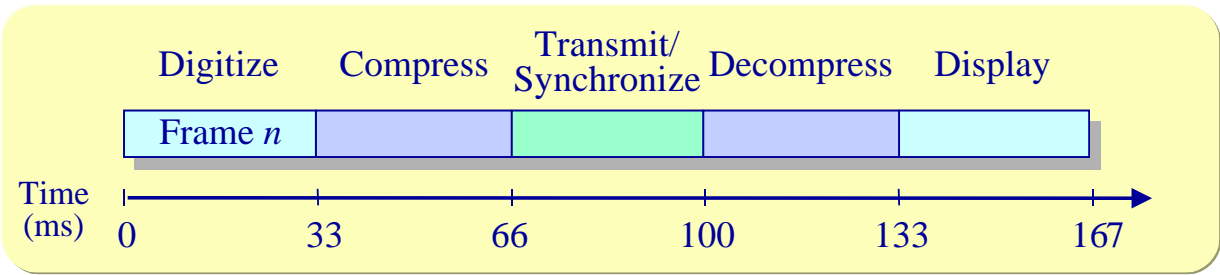
## Latency as a measure of continuity of playout



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# Understanding End-to-End Latency

## Latency as a measure of continuity of playout

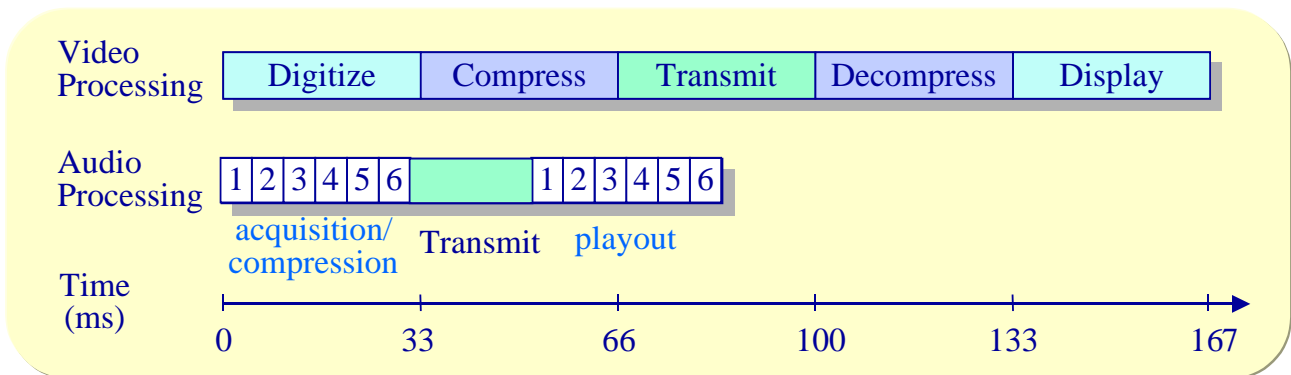


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# Understanding End-to-End Latency

## Audio performance

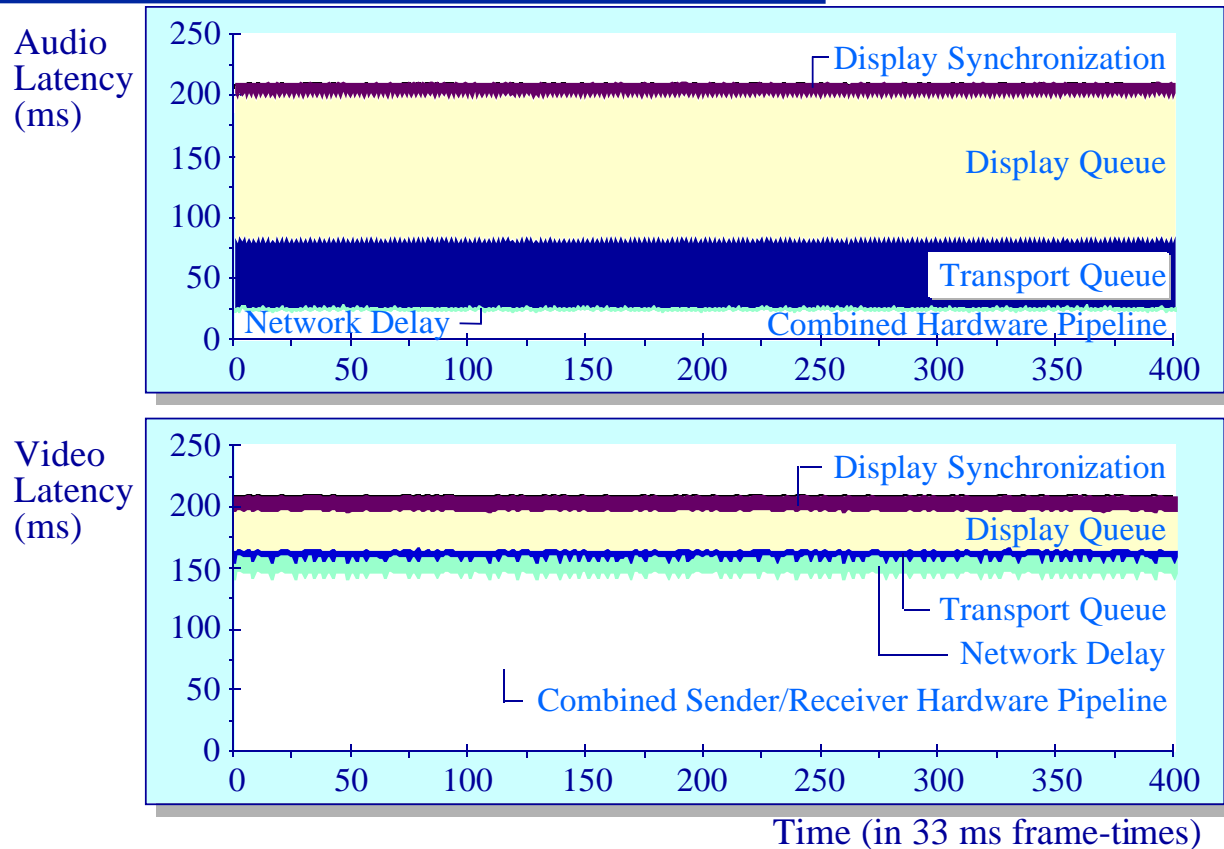
- ◆ To provide lip synchronization, audio must be delayed to “wait” for video



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# Understanding End-to-End Latency

## Latency as a measure of lip synchronization

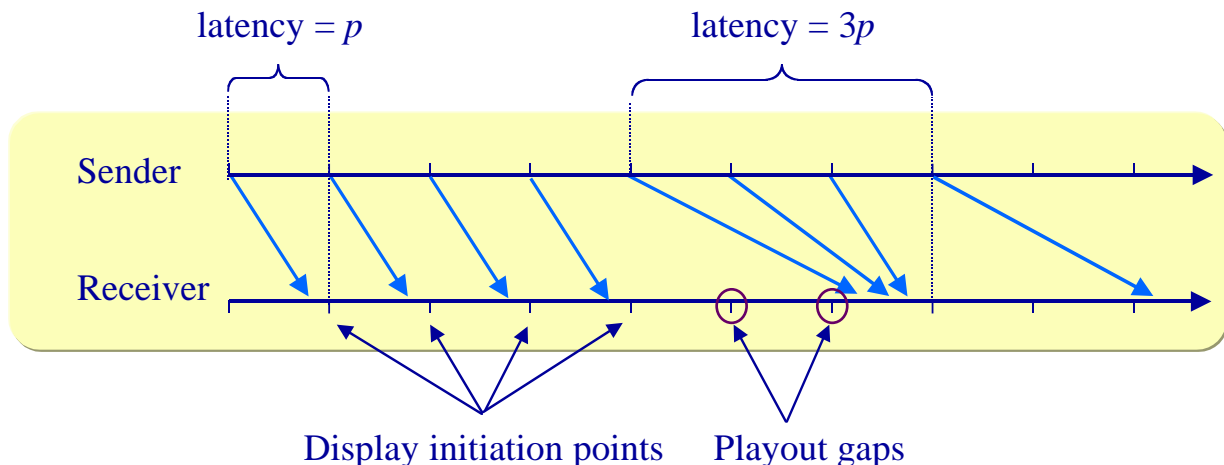


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# Understanding End-to-End Latency

## Latency as a measure of delay-jitter

- ◆ Delay-jitter increases playout latency

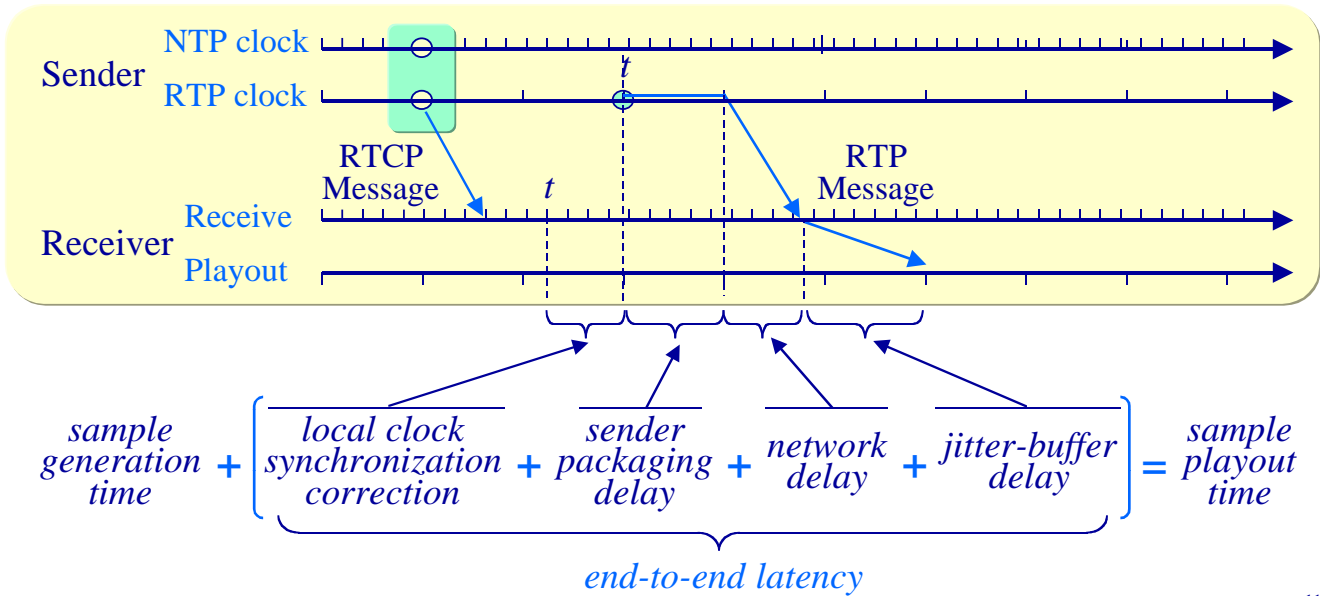


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# Understanding End-to-End Latency

## Latency as a measure of delay-jitter

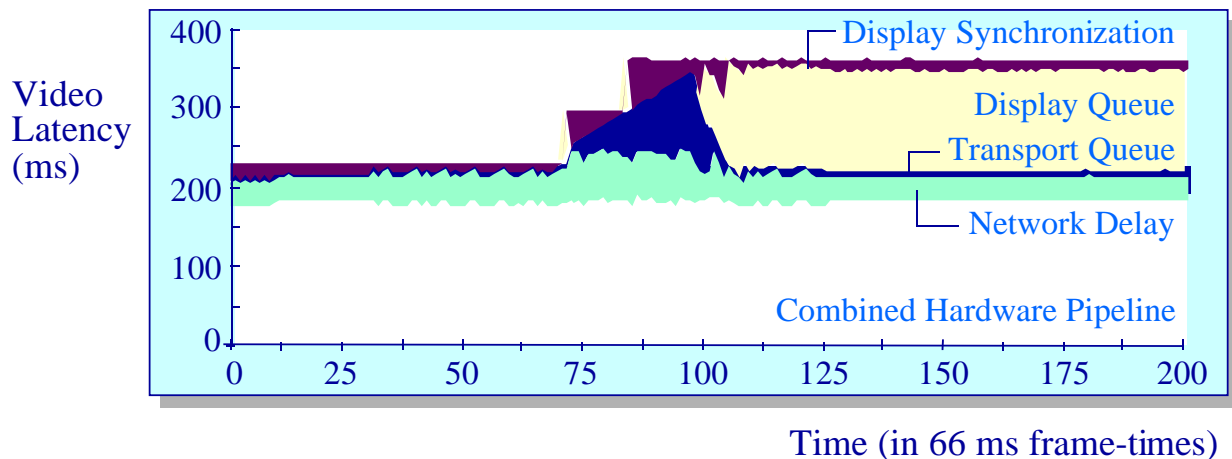
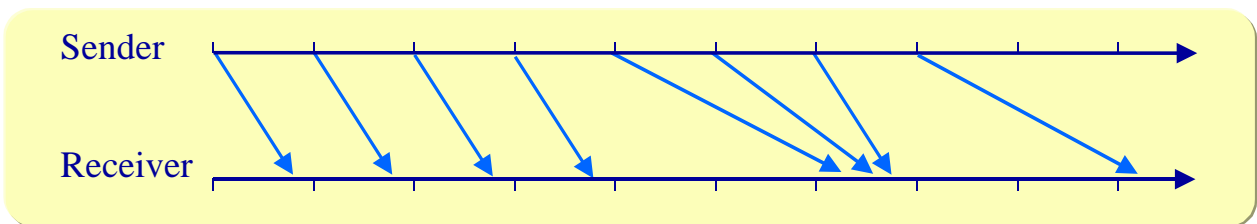
- ◆ Recall that actual playout time is not a function of the arrival time, only of the end-to-end delay
  - » The key application decision is how long to delay the initial sample prior to playout



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# Understanding End-to-End Latency

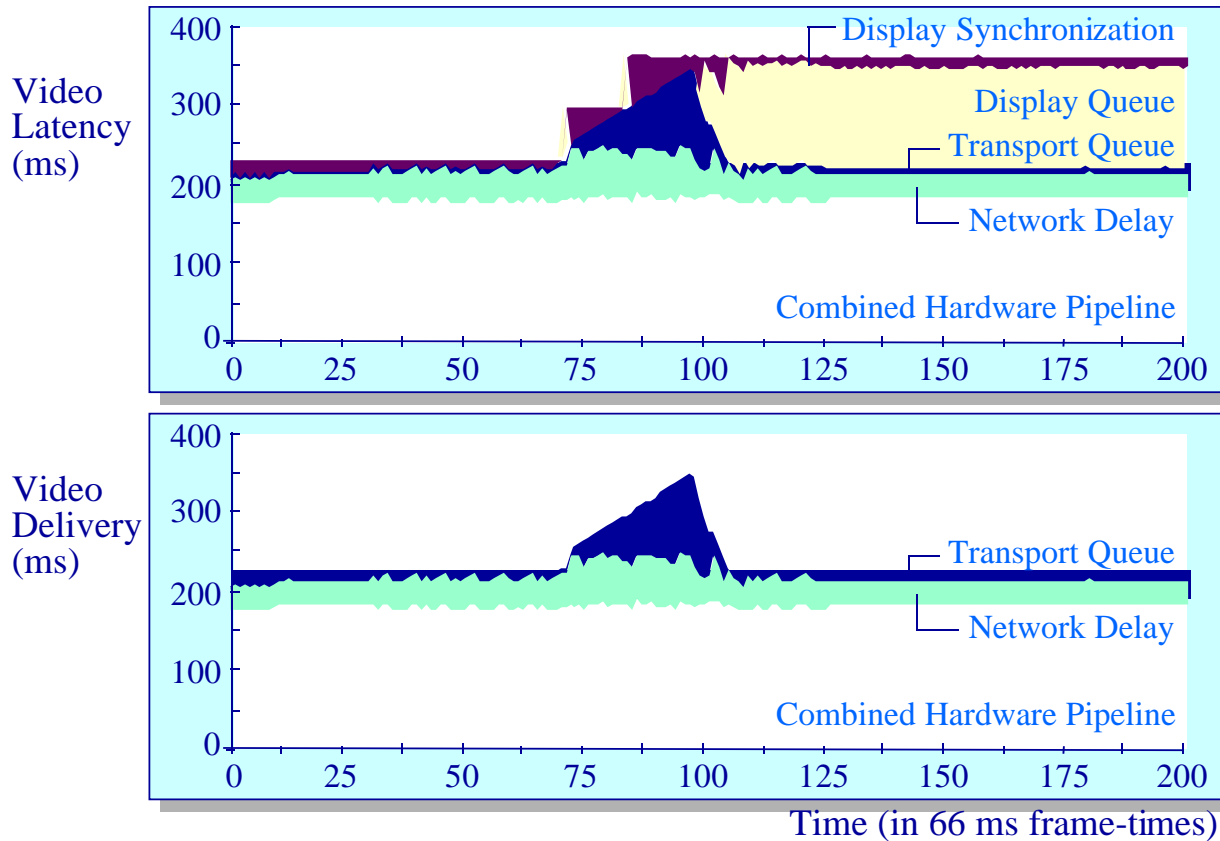
## Latency as a measure of delay-jitter



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# Understanding End-to-End Latency

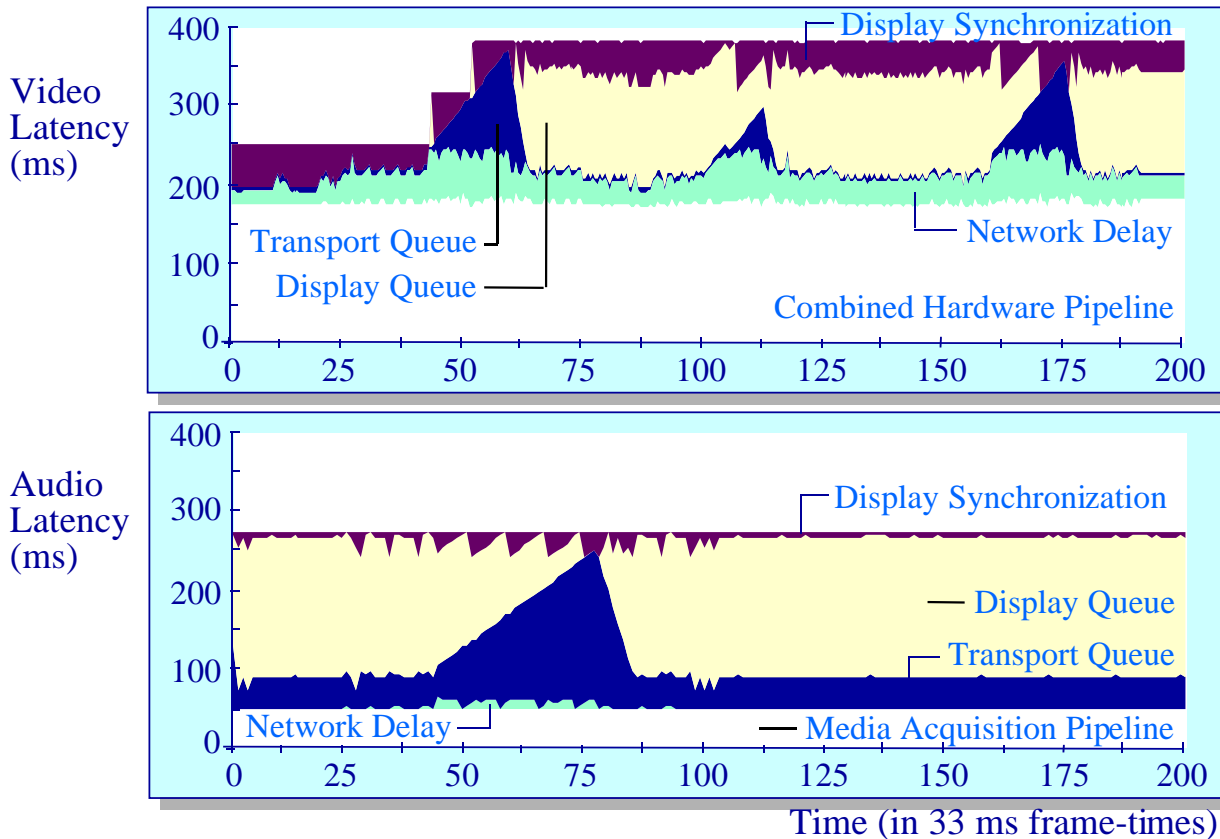
## Network v. application latency



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## Network v. Application Latency

### Is application induced latency bad?

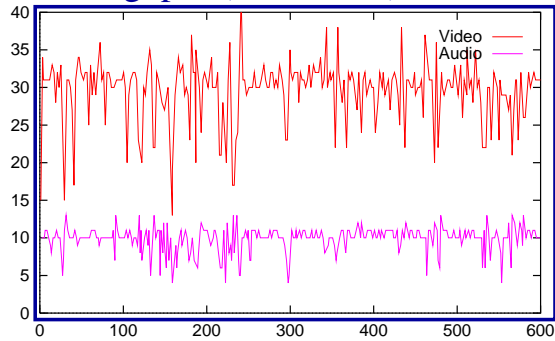


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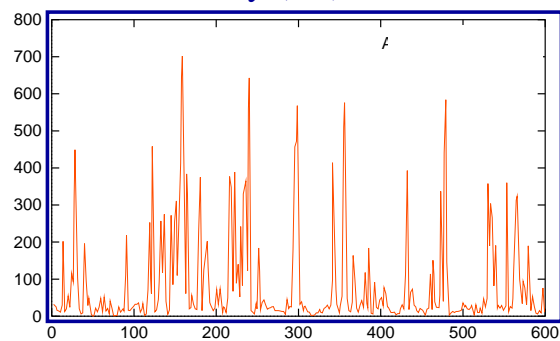
# Videoconferencing on the Internet Today

## ProShare™ performance on the Internet

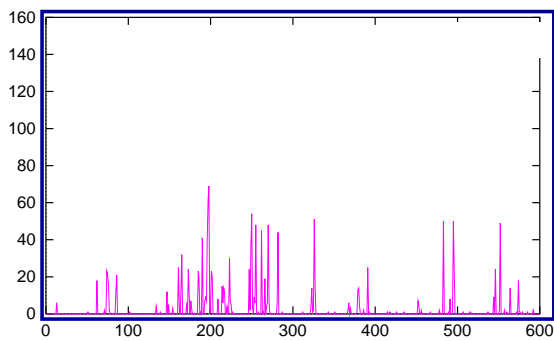
Throughput (frames/sec)



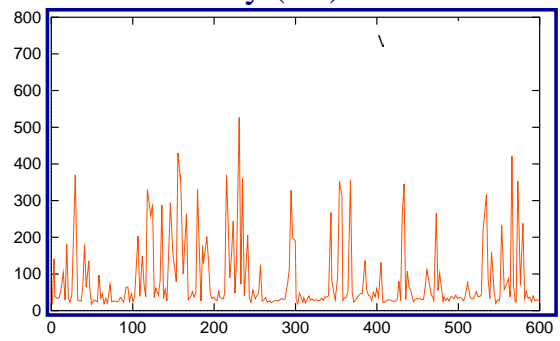
Audio Latency (ms)



Packet Loss



Video Latency (ms)

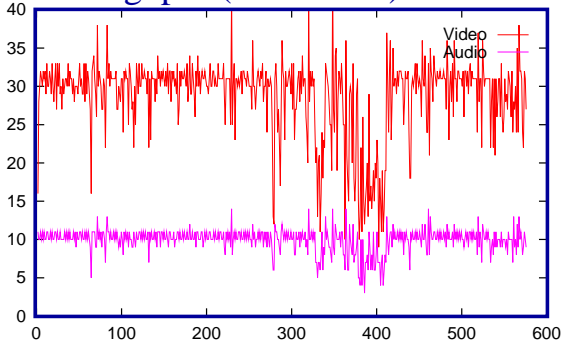


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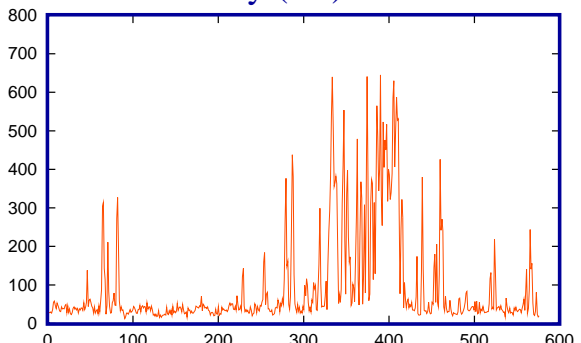
# Videoconferencing on the Internet Today

## ProShare™ performance on the Internet

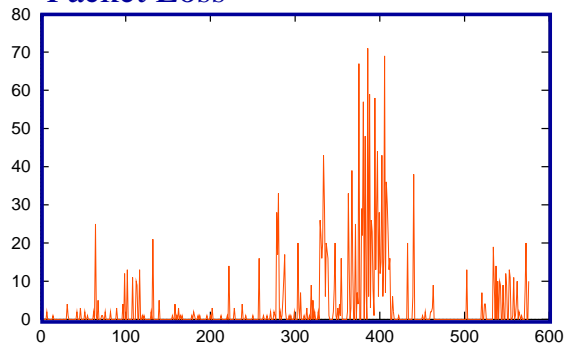
Throughput (frames/sec)



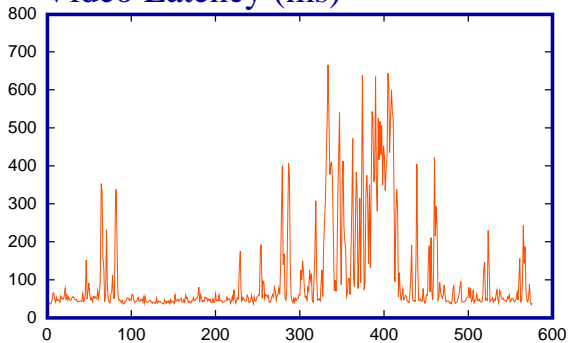
Audio Latency (ms)



Packet Loss



Video Latency (ms)

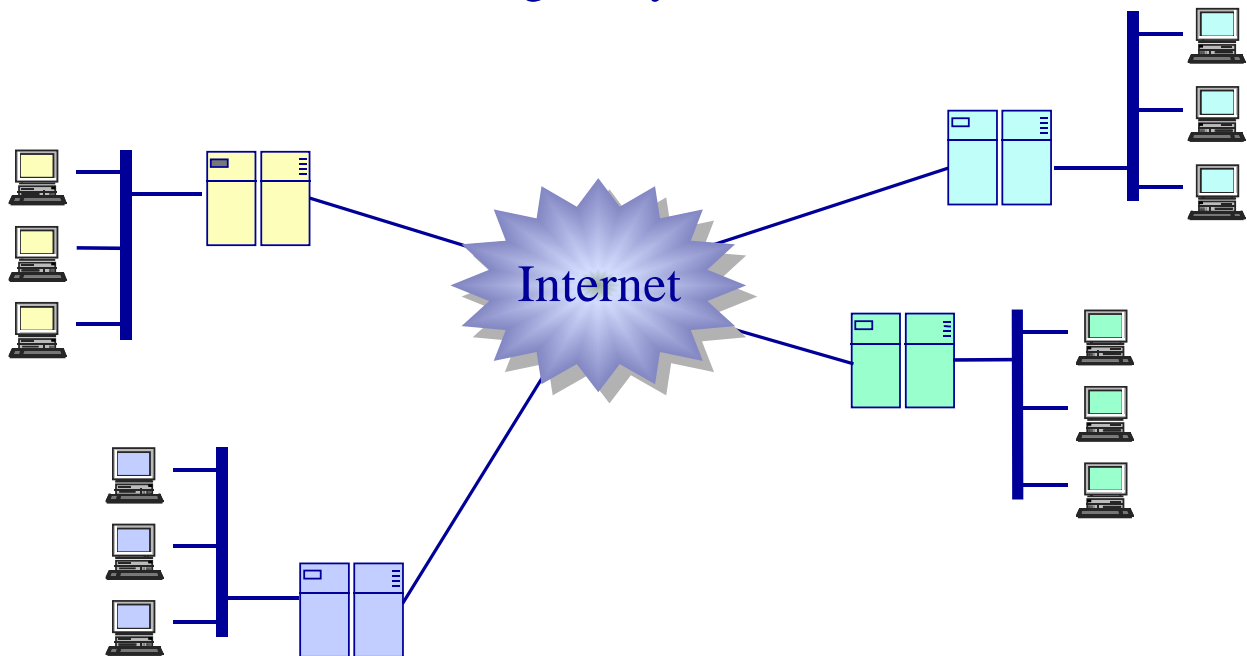


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# Videoconferencing on the Internet Today

## What's the problem?

- ◆ Where is data being delayed and lost?

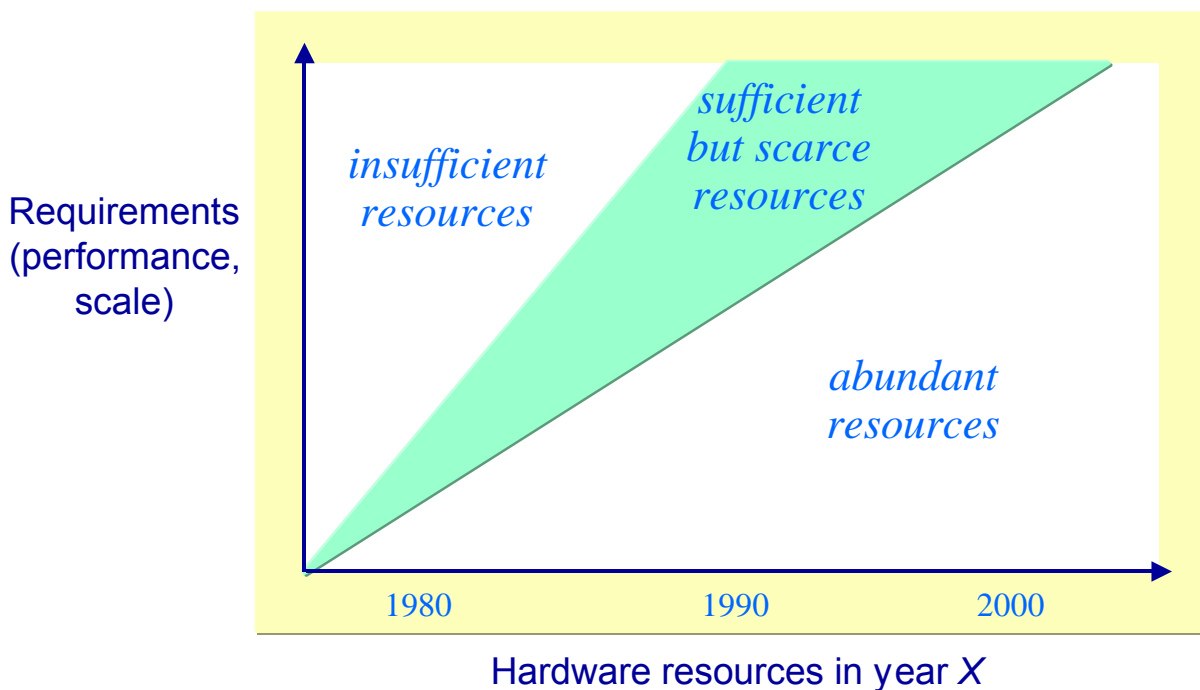


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# Videoconferencing on the Internet Today

## What's the problem?

- ◆ Do we need more bandwidth or just better management of the existing bandwidth?

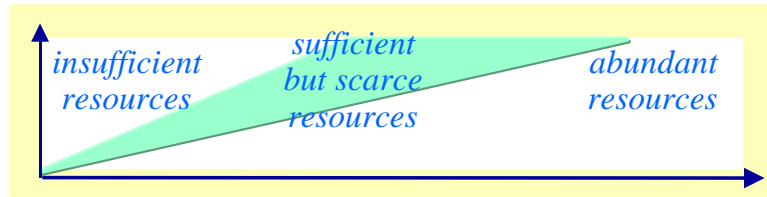


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# Where do we go from here?

## Two fundamental approaches

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- ◆ Provide true quality-of-service through reservation of resources in the network
  - » Requires coordination amongst all parties
    - ❖ admission control
    - ❖ policing
    - ❖ ...
- ◆ Provide “best-effort” service by adapting media streams
  - » Monitor & provide feedback on performance
  - » Bias transmission and processing of media to ameliorate the effects of congestion