06-06798 Distributed Systems

Lecture 17: Distributed Multimedia

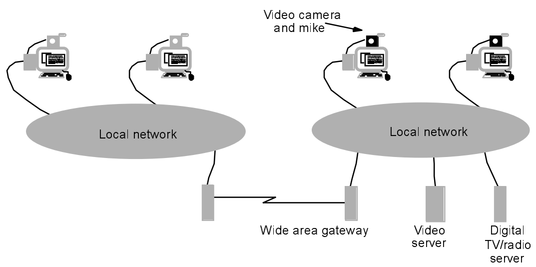
Overview

- Characteristics of multimedia systems
  - audio, video, etc
  - delivery in real time, on time
- Quality of service (QoS) management
  - QoS negotiation and guarantees
  - admission control
  - traffic shaping
    - leaky bucket
    - token bucket

Multimedia

- Multimedia data are
  - continuous streams of data, e.g. digital audio and video
- Most networks currently are...
  - best effort: no guarantee of bandwith or latency
- Requirements for multimedia
  - timely delivery to end users
  - soft deadlines rather than hard
- Applications
  - business conferencing
  - networked video libraries, video on demand
  - Internet telephony

A distributed multimedia system



Quality of Service Management

- Needed to manage resource allocation, such as
  - network bandwith
  - computing resources
  - dynamic aspects of varying number of participants
  - balance different activities, e.g. video bandwith versus phone conversation
- Multimedia-specific requirements
  - media synchronisation of different streams (lip sync)
  - external synchronisation of video conferencing with other data, e.g. simulations, animations, electronic whiteboards, shared documents, etc

Multimedia data

- Continuous
  - i.e. are sequences of discrete values which replace each other over time
- Time-based (=isochronous)
  - the times at which the values are played/recorded affect the validity of data
- But of course bulky:
  - high bandwith required, especially high quality video (e.g. 120Mbps, Ethernet is max 100Mbps)
  - compression needed, cf GIF, MPEG formats

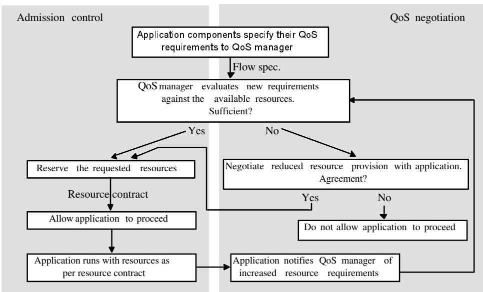
Typical multimedia streams

	Data rate (approximate)	Sample or frame size	Sample or frame frequency
Telephone speech	64 kbps	8 bits	8000/sec
CD-quality sound	1.4 Mbps	16 bits	44,000/sec
Standard TV video (uncompressed)	120 Mbps	up to 640 x 480 pixels x 16 bits	24/sec
Standard TV video (MPEG-1 compressed)	1.5 Mbps	variable	24/sec
HDTV video (uncompressed)	1000–3000 Mbps	up to 1920 x 1080 pixels x 24 bits	24–60/sec
HDTV video MPEG-2 compressed)	10–30 Mbps	variable	24–60/sec

Quality of Service Management

- Typical multimedia system architecture
  - process streams of data (audio, video)
  - transferred from source (camera, microphone)
  - rendered or consumed at target (screen, speaker)
- Responsibilities of QoS manager
  - QoS negotiation: application asks for resources, QoS manager grants them if available, otherwise renegotiation takes place
  - admission control: application holds a resource contract, which must be renegotiated if the resource requirements change

QoS Manager's Task



QoS negotiation

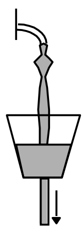
- Main parameters (often desired and worst)
  - bandwith: rate of data flow, e.g. 10 frames/sec for raw video
  - latency: time required for a data element to move from source to target; variations in latency are known as jitter
  - loss rate: data (usually less than 1%) may have to be dropped if it is late due to congestion, as otherwise timing of stream affected
- Example: a video stream (MPEG) requires
  - 1.5Mbps bandwith
  - delay at most 150 ms between frames
  - results acceptable at target if loss rate of 1 out of 100

Traffic shaping

- Buffering to smooth the flow of data elements
  - to control data elements that can arrive too early/late
- Leaky bucket
  - buffer inserted at the source
  - ensures stream never flows at rate higher than some maximum
- Token bucket
  - uses tokens to time outgoing stream
  - can be used in combination with leaky bucket

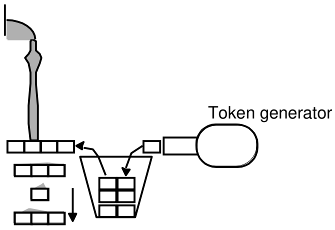
Leaky bucket

- eliminates bursty traffic pattern (buffer size should match maximum burst)
- stream allowed to flow into buffer
- outgoing rate kept below some maximum



Token bucket

- tolerates larger bursts if traffic idle
- tokens to send data generated at fixed rate, collected in bucket
- data sent only if a certain number of tokens in bucket; token removed after sending



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QoS negotiation procedures

- If a single source and target
  - source component issues request for resources to QoS manager
  - QoS manager checks available resources and passes back info about the resources it can provide
  - component decides if resources acceptable and adapts
  - contract agreed
  - resources may have to be renegotiated
- In a distributed system
  - distributed sources and sinks
  - distributed negotiation needed

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Admission control

- Resources contract: how much to ask for?
  - minimum required, maximum or average?
  - if minimum, quality poor?
  - if maximum, potentially wasteful?
- Purpose of admission control
  - based on current resources contract: avoid overloading the resources
  - turns down requests that violate existing QoS guarantees
- In distributed scenario
  - centralised admission control or distributed algorithm needed

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Admission control methods

- Bandwith reservation
  - request maximum bandwith for exclusive use
  - used for applications that cannot adapt to changing QoS levels
  - under-utilisation possible, actual usage lower
- Statistical multiplexing
  - not based on the worst case
  - aggregates streams
  - use probability, and yields soft deadlines, i.e. 'with probability 0.89, video and audio frames will be lip synchronised'

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Summary

- Multimedia data
  - continuous streams
  - time-based
- Distributed multimedia
  - best effort networks not powerful enough
  - require stricter timing - not hard deadlines, but soft
  - need Quality of Service management:
    - resource allocation
    - QoS negotiation
    - traffic shaping
    - admission control

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