Why Study Multimedia?

- Improvements:
  - Telecommunications
  - Environments
  - Communication
  - Fun
- Outgrowth from industry
  - telecommunications
  - consumer electronics
  - television

Continuous Media

- Subset of multimedia
- Includes timing relationship between server and client
- Stream:
  - video: mpeg, H.261, avi
  - audio: MP3, µ-law

Multimedia Resource Requirements

<table>
<thead>
<tr>
<th>Bytes for 1 Page</th>
<th>text</th>
<th>graphics</th>
<th>color</th>
<th>audio</th>
<th>video</th>
</tr>
</thead>
<tbody>
<tr>
<td>text</td>
<td>2K</td>
<td>38K</td>
<td>300K</td>
<td>720K</td>
<td>7000K</td>
</tr>
</tbody>
</table>

- Step up in media requires more bytes
- But not as much as some applications
  - Graphics or transaction processing

Influences on Quality

An End-To-End Problem

- Server Application
- Operating System
- Network Protocol
- Client Application
- Operating System
- Network Protocol
- Routers
**Traditional OS Support**

- **Same:**
  - arbitrate resource demands (efficient)
  - abstractions of low-level devices (convenient)
- **Different:**
  - no longer just protect memory of process
  - negotiated slice of CPU time
  - I/O bandwidth
  - timing!

**OS Problems in Supporting Multimedia**

- Process Scheduling (now)
- Memory Management (later)
- Storage Scheduling (later, cs4513)
- Network Interface (later, cs4514)

**Process Scheduling Shortcomings**

- Multi-level feedback queue
- Typical time slice 100 ms
- Dispatch latency 100 ms!
  - Varies (Jitter)

**Jitter vs. Processor Load**

**Process Scheduling Fix?**

- Priority to multimedia processes
- nice
Memory Management

- Paging:
  - page faults cause jitter
  - allocation causes jitter
    - global vs. local
  - solution: lock in pages
- Memory allocation generally not tied to scheduling priority

Network Interface

- TCP
  - guarantees delivery
  - stream semantics
  - fixed flow control
  - unicast
  - ... big bleah!
- UDP
  - multicast add-on
  - checksum cannot be turned off
  - no notion of priority
  - no flow control
  - ... little bleah!
- RTP
  - multicast add-on
  - packet sequence
  - flow control

Storage Scheduling

- Disk scheduling and layout
- DBMS

Disk Arm Scheduling

- Read time:
  - seek time (arm to cylinder)
  - rotational delay (time for sector under head)
  - transfer time (takes bits off disk)
- Seek time dominates
- How does disk arm scheduling affect ...
First-Come First-Served (FCFS)

- $14 + 13 + 2 + 6 + 3 + 12 + 3 = 53$
- Service requests in order that they arrive
- Little can be done to optimize
- What if many requests?

Shortest Seek First (SSF)

- $1 + 2 + 6 + 9 + 3 + 2 = 23$
- Suppose many requests?
  - Stay in middle
  - Starvation!

SCAN (Elevator)

- $1 + 2 + 6 + 3 + 2 + 17 = 31$
- Usually, a little worse than SSF
- C-SCAN has less variance
- Note, seek getting faster, rotational not
  - Someday, change algorithms

Redundant Array of Inexpensive Disks (RAID)

- 38 disks
- Pull data in parallel
- Form 32 bit word, 6 check bits

Conclusion

- Much work to be done
  - scheduling
  - memory management
  - network
  - disk
- MQP anyone?
  - One piece in OS support puzzle