Multimedia Applications

- Media Synchronization
- Multimedia Conferencing
- Multimedia Documents and Presentations

Media Synchronization

- Multimedia applications display multiple steams (video, stereo audio)
- Servers access and transmit each stream independently
- Problem: Application must synchronize multiple data streams prior to playback
- Simple Approach
  - Timestamp packets/frames/samples in each stream at creation time
  - Synchronize assuming globally synchronized clocks

Synchronization: Challenges

- Each stream may be recorded at different times
- Clocks at server and client may not be synchronized
- Network delays may vary over time

Synchronization using Relative Time Stamps

- Do not assume any synchronization between server and client
- Use relative time stamps (RTS)
  - Designate a master stream and others are slave streams
  - RTS indicates the temporal position relative to master's media units
  - Can handle streams generated by different sources at different times
- Server employs periodic feedback messages sent by the client to track stream playback
- Asynchrony: take corrective action (delete, duplicate media units)

Multimedia Conferencing

- A conference involves a live communication between several parties
- May involve audio, video, text and images
- Challenges
  - Live transmission of data $\Rightarrow$ low delay tolerance ($<$ 150ms)
  - Protocol to initiate a conference
  - Floor control protocol
  - Dynamic membership control
  - Call filtering, call forwarding, simultaneous speakers ...

Conferencing using Etherphone (circa 1990)

- Uses conventional ethernet for transmitting data
- Supports both audio and video
- Connection manager: user registration, call initiation, call notification
- Transport agent: manage media streams
  - Multicast audio server
  - Video server
- Control agent: provides user interface

Multimedia Documents and Presentations

- Multimedia documents consist of multiple data types
- Data types can have both spatial and temporal relationships
- Document architectures (SGML, MHEG...)
  - Content (e.g., audio clip, gif image, text...)
  - Structure (hyperlinks, synchronization)
  - Presentation and manipulation model
    - Non-linear structure (hyperlinks)
    - Temporal relationships in the presentation

Multimedia Presentation Example

Other Multimedia Applications

- On-line Virtual worlds
  - Artificial worlds that can be navigated using virtual reality aids
  - Useful for training firefighters, pilots, ...
  - Challenge: store and retrieve and navigate large amounts of terrain information
- Multi-player multimedia games
  - Play a game in a large synthetic world
  - Several thousand simultaneous players
  - Challenge: send state updates to all relevant players

Snapshot of Research Horizons

- What we talked about
  - Compression techniques
  - Storage models and structures
  - Operating system support
  - Digital audio and video networking and communication architectures
- What we did not talk about
  - Media synchronization
  - Methodologies, tools, and software architectures for multimedia collaborative applications
  - Multimedia document architectures
  - Multimedia database management, content-based retrieval techniques
  - Hardware architectures

Concluding Remarks: What You Should Take Away

- The field multimedia spans several disciplines (OS, networking, distributed systems, CHI...)
- Increasing importance with the growth of the World Wide Web
- Researchers
  - Relatively nascent fields $\Rightarrow$ rapid advances and changes
  - Several open problems $\Rightarrow$ fertile ground for research
  - Research methodology
- System designers
  - Designing multimedia systems poses new challenges and requirements
  - Managing heterogeneity is key
  - Compatibility with standards