Multimedia = audio and video

- Saroiu et al.—An Analysis of Internet Content Delivery Systems
  - How is multimedia distributed over the Internet?
  - How much is there?

- MacCanne et al.—Receiver-Driven Layered Multicast
  - How to best stream multimedia across the Internet?
Stefan Saroiu’s OSDI Talk
Streaming Multimedia

- Based on broadcast model
  - One server, many clients
    - Clients subscribe to streams
- Basic problem: Network heterogeneity
  - One approach: Fixed rate, least common denominator
Better Approach: Layered Transmission Scheme

- Basic idea: Encode signal in many layers
- Each layer provides better quality
- Sum of layers represents a *session*
  - Cumulative layers
  - Independent layers
    - Simulcast
Underlying Network Model

- Three assumptions
  - Best effort, multipoint packet delivery
  - Efficiency of IP Multicast
  - Group-oriented communication

- Important issue: router drop policy
The RLM Protocol

- Basic control loop
  - On congestion, drop a layer
  - On space capacity, add a layer
Capacity Inference

- One option: Monitor link utilization in network
  - Problem: requires changes to network
- Another option: Actively probe network
  - Join-experiments
- Issues with join-experiments
  - Adaptability
  - Scalability
Join-Experiment Adaptability

- **Goal**
  - Perform infrequently when likely to fail
  - Perform frequently when likely to succeed

- **Algorithm**
  - Join-timer for each layer
  - Exponential backoff for problematic layers
Join-Experiment Adaptability (cont.)

- How to correlate join-experiment with outcome?
  - Need to chose appropriate detection-time
    - Unknown
    - Variable
  - Use estimator
    - Initialize conservatively
    - Adjust based on failed join-experiments
Join-Experiment Scalability

- Issue: interaction of independent join-experiments
  - Add congestion
  - Interfere with each other

- Approach: scale frequency with group size
  - But, what about convergence?
Join-Experiment Scalability
Shared Learning

- Receiver notifies group of join-experiment
- On congestion, other receivers increase corresponding join-timer
  - Conservative
  - Local
More on Shared Learning

- Join-experiments are not completely exclusionary
  - Lower or equal level experiments may overlap

- What about router drop policy?
Evaluation

- Based on simulations (ns)
- Two metrics
  - Worst-case short-term loss rate
  - Convergence time to sustainable throughput
- Four topologies
  - Latency scalability
  - Session scalability
  - Bandwidth heterogeneity
  - Superposition
Results

- **RLM**
  - Is sensitive to transmission latency
  - Scales with group size
    - Though, convergence time increases!
  - Supports bandwidth heterogeneity
    - Though, with increased loss rate
  - Supports simultaneous sessions
    - Though, allocation was often unfair
What Did You Learn Today?

- Content distribution in the Internet
- Receiver-driven layered multicast