Enabling DVD-like Features in P2P Video-on-demand Systems

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Video-on-Demand

• Customer demand
  – Real-time TV streaming (e.g., PPLive)
  – Downloads of popular TV shows day or two after the first airing

• Commercial push
  – YouTube, AOL, MSN, Yahoo, etc. video service
  – iTunes, Unbox, etc.

• Media companies (finally) realizing the benefits, developing new service models
VoD Advanced Features

• DVD features
  – Pause, skip (seek), fast-forward (watch a boring movie at 1.25 X speedup)
  – Large selection
  – Substantial latency (click on netflix.com&wait)

• Digital video recorders are popular (TiVo, ReplayTV)
  – Record favorite shows, watch later
  – VCR-like features
  – Selection limited to cable channels
Accommodating Random Seeks/FF

• Most deployed large-scale Video-on-Demand systems and proposals do not have VCR/DVD features

• Random Seeks/FF present a problem:
  – If large fraction of nodes seek past the last current playpoint $\rightarrow$ increased source load
  – If a node seeks and is unable to find blocks $\rightarrow$ increased source load
BulletMedia

• Use proactive caching in a P2P VoD system to establish and maintain multiple copies of content in-overlay
• Provide a mechanism to allow quick discovery of a specific block in-overlay
Outline

• Introduction
• BulletMedia
• Evaluation
• Related Work
• Future Work
High-bandwidth overlay mesh
Structured overlay used to enable proactive caching and advanced operations
Playback Buffer and Content Cache

- Media file decomposed into fine-grained blocks
• RanSub delivers random subsets of potential peers, along with their summaries
• Peering algorithm determines # of peers
• Slow senders and receivers are disconnected
• Requests disjoint range of data objects from each sender
• Feedback control loop adjusts maximum amount of outstanding data
Structured Overlay

• Answer question: which peer(s) have a required block?
• Distributed Hash Table (DHT) stores metadata about content location within the mesh overlay
• Contiguous blocks grouped into chunks (e.g., 100 blocks in a chunk)
  – Replication/random seek unit
• All blocks for chunk are present → insert an entry into the DHT
Random Seek Behavior

- Check the locally available block maps for mesh senders
- Block unavailable → determine the chunkId and query the DHT
  - DHT returns a (bounded) set of peers for chunkId → choose randomly one or more of the returned peers
Managing the Content Cache

• Proactive caching to ensure diversity of blocks stored in the overlay
• Replicate media file at least $k$ times (a la TotalRecall [Bhagwan et al., NSDI ’04] )
• Peer uses its spare bandwidth to prefetch blocks in advance
Managing the Content Cache (cont’d)

• Peer examines its local content cache and picks a random chunk it does not have
• Peer queries the DHT for chunk’s current replication factor \( r \)
  – If \( r < k \), retrieve chunk (avoid source if possible)
  – Else query for different chunk
Evaluation Methodology

- Live experiments with 100 participants multiplexed onto 8 physical nodes (16 CPU cores)
- BulletMedia implemented in Mace [Killian et al., PLDI ’07]
- ModelNet [Vahdat et al., OSDI ’02] emulating wide-area Internet-like network characteristics
  - 5000-router INET topology:
    - 2 Mbps homogenous access links, 100 Mbps core
    - 14 Mbps source outbound bw
Evaluation Questions

• Can BulletMedia peers replicate the file the required number of times?
• Can the system accommodate a large number of random seek requests without stalling the video playback?
Random Seek Scenario

- 50 MB movie, 600 kbps rate, 16 KB blocks, 1.6 MB chunk
- Minimum playing rate is set to 0.8
- Flash crowd at t=0 sec
- 50% of nodes seek forward at t=200 sec
  - Play for 40 to 60 seconds before seeking again
Block Replication (k=4)
File Replication

Percentage of file replicated vs. Time (s)

Proactive caching vs. Baseline
Random Seek Performance

Fraction of nodes that can play vs. Time (s)

Proactive caching vs. Baseline
Related work

- CoolStreaming [Zhang et al., Infocom 2005], GridMedia, PPLive
- RedCarpet [Annapureddy et al., Infocom 2007]
- Peer-Assisted VoD [Huang et al., SIGCOMM 2007]
Conclusion

• BulletMedia effectively leverages excess end-host bandwidth to provide
  – Better service and
  – DVD-like functionality for p2p VoD systems
Questions