Towards a QoE-aware P2P Video-on-Demand System

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Live Streaming vs. VoD

- P2P Live Streaming: Video content encoded on-the-fly and delivered to all peers nearly simultaneously

- P2P VoD Streaming: Video content already available, different playback positions of the peers

<table>
<thead>
<tr>
<th>Network Parameters</th>
<th>Impact on Live Streaming (UDP)</th>
<th>Impact on VoD (TCP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packet loss</td>
<td>Loss of information, artifacts, stalling, stream starvation</td>
<td>Retransmissions, impact on TCP control loop</td>
</tr>
<tr>
<td>Insufficient available bandwidth</td>
<td>Leads to packet loss</td>
<td>Higher startup delay, frequent stalling</td>
</tr>
<tr>
<td>Delay</td>
<td>Higher startup delay, less “live” experience</td>
<td>Higher startup delay, possible impact on bandwidth</td>
</tr>
<tr>
<td>Jitter</td>
<td>May lead to packet loss (jitter buffer to small; VLC e.g. 300 ms)</td>
<td>Practically none</td>
</tr>
</tbody>
</table>
Motivation – P2P VoD Streaming

- Support different access technologies
- Support different user devices

Core Network

Access Network

Access Network

Access Network

Support different access technologies

Support different user devices

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Agenda

- Motivation
- QoE for video transmissions
  - QoE management
  - Impact of QoS on QoE
- P2P VoD System
  - Peer and chunk selection mechanisms
  - Scalable video coding
  - Scenario description and results
- Conclusion
QoE Management

- QoE degradation due to bad network conditions, e.g. bandwidth
  - empty buffers and stalling (TCP)
  - packet loss and artifacts / stream starvation (UDP/RDP)
  → Negative, uncontrollable impact on the QoE (success related)

- Bandwidth saving feasible by reducing:
  - resolution
  - frame rate
  - image quality
  → Negative, but controllable impact on QoE (resource related)

→ Comparison of the different impact factors on the video QoE
Motivation – Scalable Video Codec

- Many forms of internet connections

- Possible solutions
  - Same file for each device and connection
  - One file for each device and connection
  - One multi-layer file

- Scalable video codec
  - Adapted to user’s requirements
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H.264 / SVC

- Extension of H.264/AVC single layer codec

- Encoding in one bit stream with different qualities:
  - resolutions (spatial)
  - frame rates (temporal)
  - image quality (quality)

- Enables code adjustments with respect to:
  - user device
  - network conditions

→ Seamless switch between different layers enables QoE management
Delivery-Provisioning Hysteresis

- Controlled and uncontrolled video distortion as function of goodput (application perceived throughput)
Frame Rate vs. Resolution

- 720p video clip with 30 fps provided best user perceived quality

Resolution / Image quality reduction outperforms frame rate adaptation in terms of bandwidth savings and video quality.
QOE-AWARE P2P-VIDEO-ON-DEMAND SYSTEM USING SVC
P2P-VoD based on Tribler

- P2P VoD System Tribler (P2P-Next)
- BitTorrent extension
  - Designed for file-sharing
- Adapted peer and chunk selection algorithms:
  - Give2Get algorithm replaces Tit4Tat
  - Chunk selection modified w.r.t. time awareness
- Suitable for VoD services
- Our approach: Enhance Tribler to support scalable video coding
**SVC Chunk Selection**

- Arrangement in priority windows
- Adaptation of priority window approach to SVC
- Lower enhancement layers are favored
- Temporal enhancement layers are preferred to spatial ones
Objective Quality of Experience

- Parameters measured in simulation study
  - Based on Protopeer

- Average number of layers played out
  - One value for temporal, spatial scalability each

- Delay to playout start interval
  - Time interval from peer start event to playout start

- Stalling times
  - Sum of all stall events of one peer

- Length of the inter quality switching time
  - Vector of all time intervals with same quality
Investigation of Different Seeding Strategies

- Scenario setup:
  - Two peer classes: DSL 1000, DSL 2000 with 128 kbps, 192 kbps upload capacity
  - 40 server with 512 kbps upload capacity (each 4 upload slots)

- Comparison of two seeding strategies:
  - Normal seeding strategy: no download after watching the video
  - Interested after strategy: chunks demanded after watching the video

- Investigation with regards to remaining online time
Impact on Playback Quality

- Normal seeding strategy better at small seeding times
- More enhancement layers for DSL 2000 peers
- Increased quality with longer remaining online time
Impact on Initial Delay

- Reduced delay with increasing remaining online time
- No difference between peer classes
- Normal seeding strategy outperforms interested after strategy
Conclusion

- Influence of network QoS on user perceived quality for video streaming:
  - Controlled quality degradation outperforms uncontrolled degradation
  - Frame rate adaption should be avoided

- Discussion of a QoE-aware P2P VoD system:
  - Enables easy adaptation of user’s QoE to provided resources
  - Peers which finished play back should not download further chunks

- Future work:
  - Further investigation of P2P VoD (including measurements)
  - Enhancement of QoE Hysteresis with FEC
  - QoE Model for Stalling
  - Media-aware network element for maximizing QoE for SVC streams
Thank you for your attention!
Impact on Stalling

- No stalling times with normal seeding strategy
- Remaining online time of 900 s with interested after strategy
- Smaller stalling times for DSL 2000 peers
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Tribler Peer Selection

- Based on G2G algorithm
  - Prefers peers with good uploading behavior
  - Discourages free riders
- Rates every peer before sending data
- Asks grandchildren about peer-behavior