An advanced network based method for Video QoE estimation based on throughput measurement

EuroView 2012
23-24 July 2012, Würzburg

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Motivation

**Video streaming measurement becomes vital**

- Video network transport quality needs to meet the video playout quality requirements (QoS <> QoE)

- Network operators want to ensure sufficient transport quality (QoS) for desired video QoE

- Therefore: video QoE measurement method required → can be used for network planning and traffic engineering
KPIs for Video QoE

Minor KPI:
• Fine grained pixel and block structure errors

Most important KPI:
• Occurrence of stalling events
Classification of Video QoE Measurement Methods

Video quality estimation based on network throughput

- Throughput measurement for each video stream
- Can be performed in client (via app) or network (via DPI)

Video quality measurement based on playout buffer level

- No video impairment is expected, if playout buffer depletion is avoided
- Fill level thresholds provide early warnings about pending buffer depletion
- Exact method (client-based): direct playout buffer level measurement in client
- Estimation methods (network-based): playout buffer level estimation within the network
Estimation Method based on Video decoding:

- Platform and end device independent estimation
- Observation of video packet flow between the YouTube server and the watching/evaluating client
- Point of Measurement at Gi-interface
- PCAP traces of different video streams (360p … 1080p resolution) for offline processing (TCP Ack)s
Estimation Method based on Video decoding

Observations:
• Take ACK timestamp for better timing precision (relative timing to first video payload segment)
• Consider TCP’s accumulated ACK behaviour
• Consider TCP retransmit for timestamps and video decoding
• Differences in FLV and MP4 playout encoding
• Modelling of buffer depletion events (playing mode / buffering mode)
Estimation Method based on Video decoding

Throughput vs. Playout buffer Estimation:

- Steep initial buffering phase followed by a fluctuating increase of buffered video data
- One re-buffering event of 6.9 sec duration
- In conformance with recorded QoE (~ 6 sec outage)
Estimation Method based on Video decoding

Observations (Throughput vs. Playout buffer Estimation):
• Throughput relevant information was extracted from the traces by header information decoding or the simple packet statistic:
  ▪ total size of the video
  ▪ video playout time
  ▪ total time of transmission of the video file

• Test: average required throughput of 2.1Mbit/s. → 2.28Mbit/s achieved

• 3 major throughput fluctuations observed; only one resulted in buffer depletion
Estimation Method based on Throughput

Estimation Method based on Throughput (within chunks)

- Same concept as in Estimation Method based on Video decoding algorithm
- Buffer fill level calculation not for each packet

- Decoding of video header only
- Fill-level calculation based on extracted chunk sizes and the amount of observed data streamed
- Variable look-up interval → trade off of processing speed-up and accuracy
Estimation Method based on Throughput

Observations:
- Processing speed-up
- Loss in accuracy depending on the look-up interval
- Correct calculation of number of re-buffering events for small interval
- Immediate impairments in re-buffering time calculation
Combined Estimation Method

- Toggling between Estimation Method based on Video decoding and the Estimation Method based on Throughput
- In good cases (buffer fill level above a certain value):
  - Estimation Method based on Throughput (within chunks)
- In bad cases (buffer fill level below a certain value):
  - Estimation Method based on Video decoding
  - Variable look-up interval
Combined Estimation Method

Observations:
• Processing speed-up
• Speed-up not as high as in the estimation method
• No loss in accuracy in calculation of number and duration of re-buffering events
• Same results as with Estimation Method based on Video decoding
Evaluation

Estimation Method based on Video decoding:
• User feedback protocols for initial buffering time, total re-buffering time and number of re-buffering events
• Traffic has been recorded as PCAP files
• Good match between user feedback protocols and calculated results

Estimation Method based on Throughput and Combined Estimation Method:
• Same PCAP files have been used as in Estimation Method based on Video decoding
• Results were compared to user feedback protocols and results of the Estimation Method based on Video decoding
• Equally good match between user feedback protocols and calculated results
## Evaluation

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<th>estimation interval stepping</th>
<th>processing time</th>
<th># re-buffering events</th>
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Key Results and next Steps

- Measurements based on throughput leads to inaccurate results
- Network based Video QoE estimation leads to valid and accurate outcomes with both of our methods
- Estimation based on Throughput combined with header extraction speeds up the processing but leads to a loss in accuracy
- Combined Estimation Method speeds up the processing with the same accuracy in calculation as the Estimation Method based on Video decoding

- Refinement of the YouTube video quality estimation → online estimation instead of traces
Backup
Comparison of the Methods

Buffer Level

- exact
- 10 Packets
- 50 Packets
- 100 Packets

buffered video time vs. real time
Comparison of the Methods

Buffer Level

buffered video time

real time

exact
10 Packets
100 Packets
Comparison of the Methods

Buffer Level

buffered video time

real time

exact
10 Packets
50 Packets
100 Packets
150 Packets
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**Video quality estimation based on playout buffer level and throughput (combined method)**

- Playout buffer based with throughput speedup: to improve network based method