A Network based Method for Quality Estimation of TCP based Progressive Download Video Services

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Contents

- Motivation
- KPIs for Video QoE
- Classification of Video QoE Measurement Methods
- Video QoE Measurement
  - Estimation Method based on Video decoding
  - Estimation Method based on Throughput
  - Combined Estimation Method
- Adaptive Streaming
- Evaluation
- Key Results and next Steps

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
  (especially for paid video services like YouTube pay channels)
  http://www.youtube.com/user/BabyFirstTVChannel

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

KPIs for Video QoE

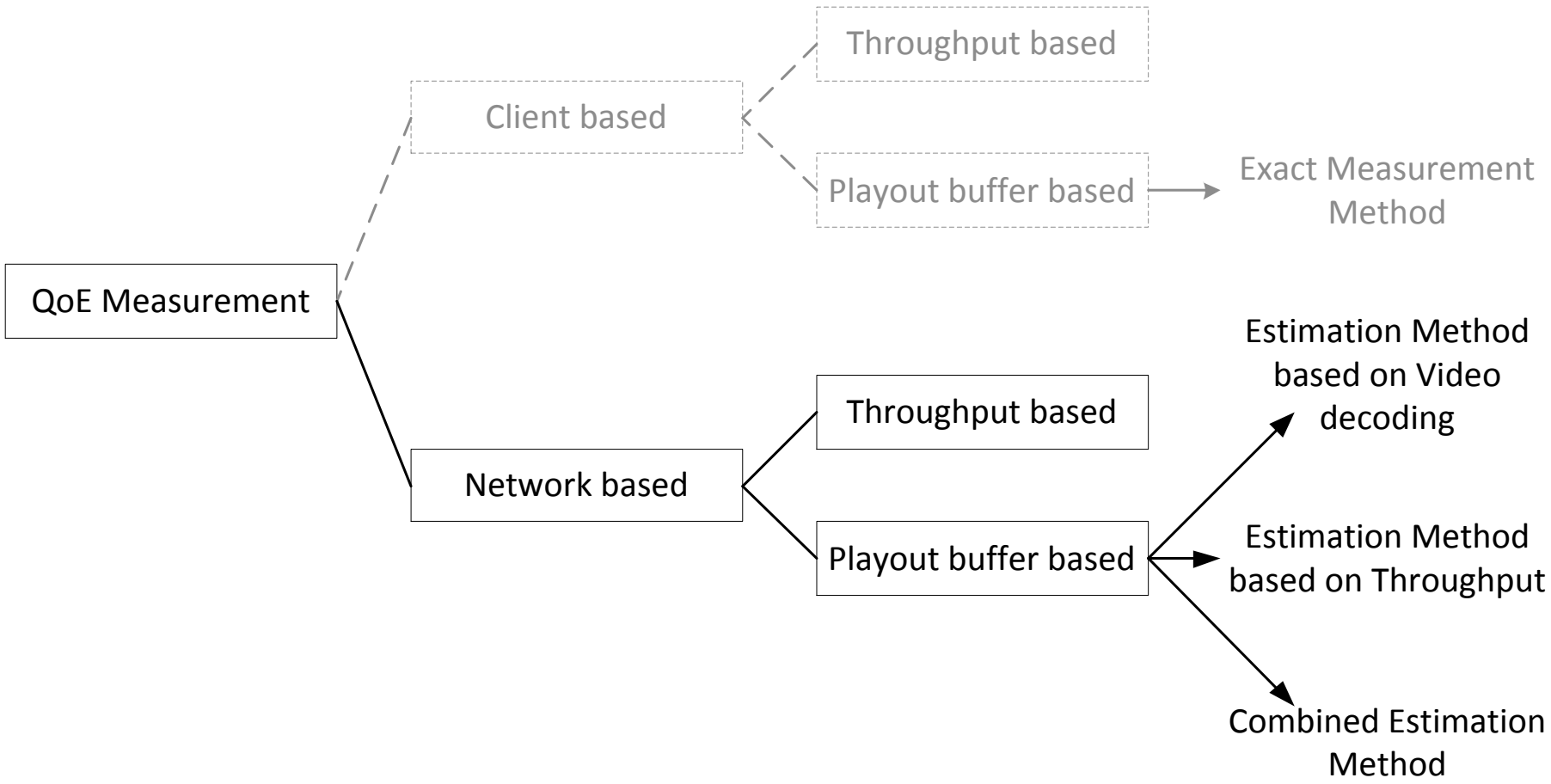
Minor KPI:

- Fine grained pixel and block structure errors

Most important KPI:

- Occurrence of stalling events

Classification of Video QoE Measurement Methods



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

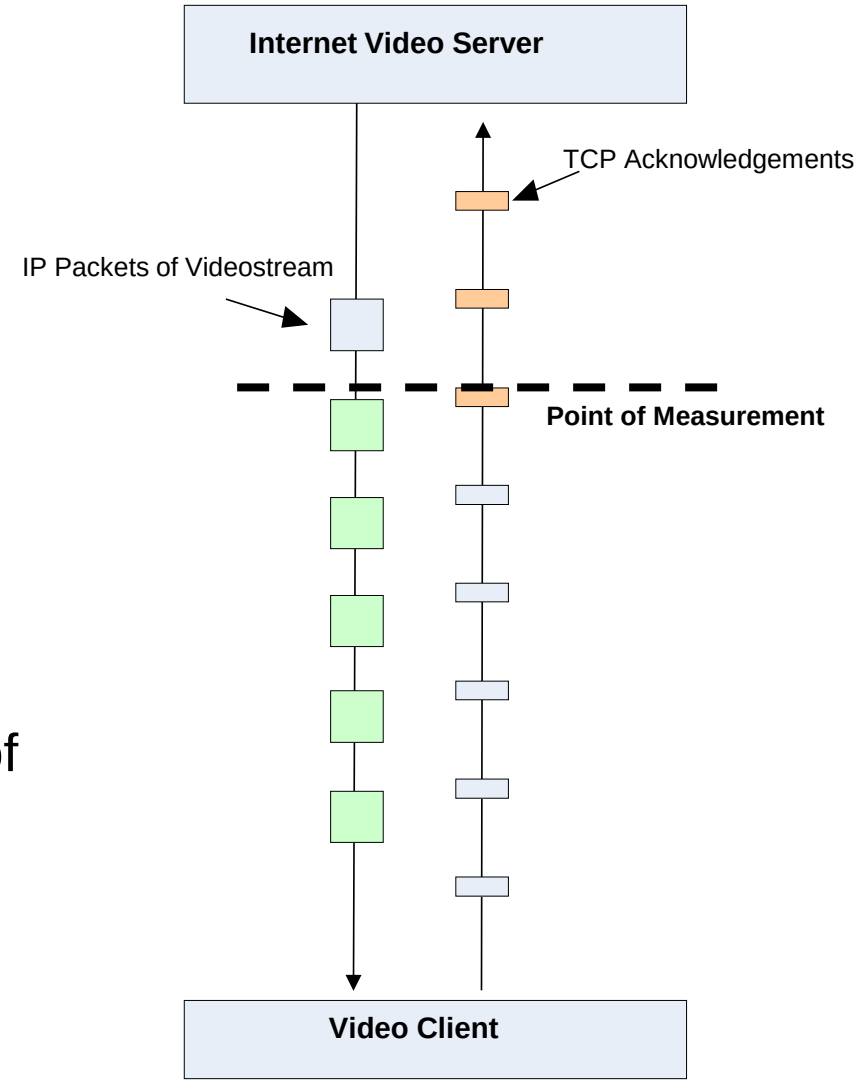
- No video impairment is expected, if playout buffer depletion is avoided
- Fill level thresholds provide early warnings about pending buffer depletion
- Exact method (client-based): direct playout buffer level measurement in client
- **Estimation methods (network-based): playout buffer level estimation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

Estimation Method based on Video decoding

Estimation Method based on Video decoding:

- Platform and end device independent estimation
- Observation of video packet flow between the video server and the watching/evaluating client
- Point of Measurement at SGi-interface

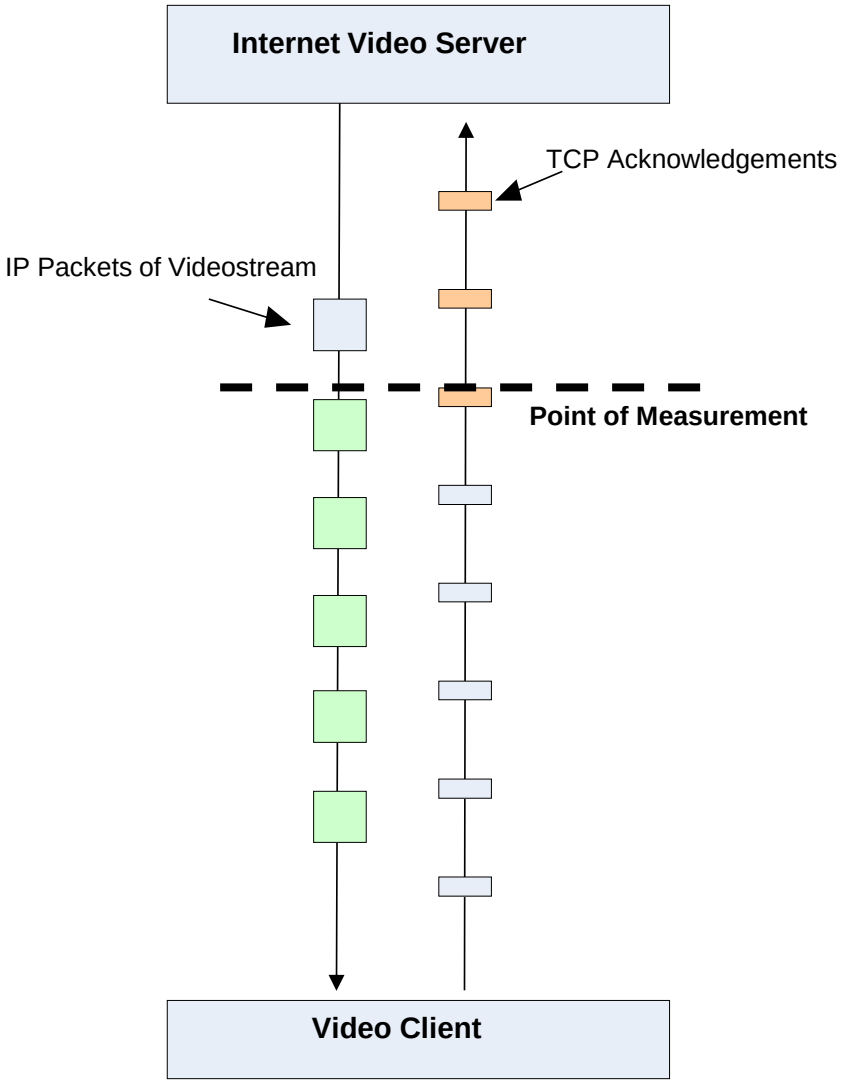
- Online & Offline packet processing of different video streams (360p … 1080p resolution)



Estimation Method based on Video decoding

Observations:

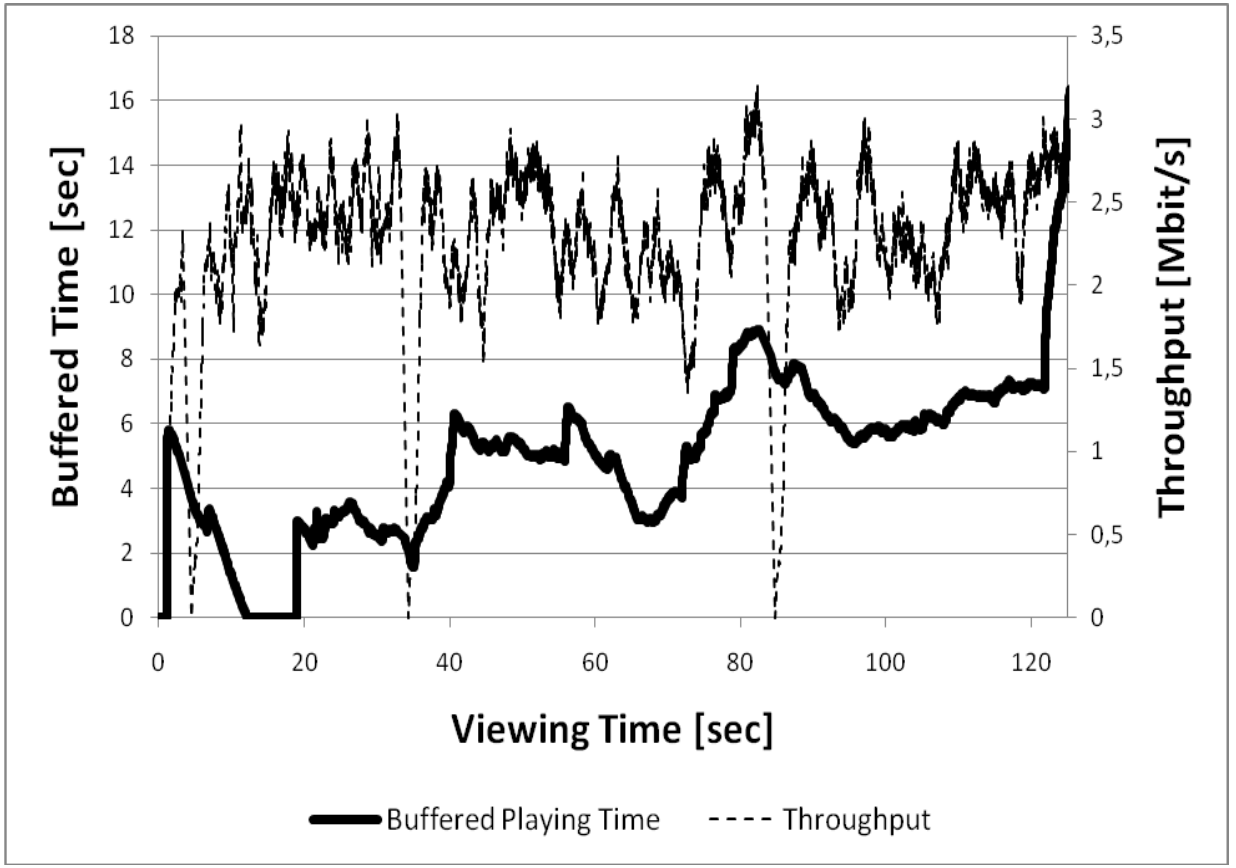
- Take ACK timestamp for better timing precision (relative timing to first video payload segment)
- Consider TCP's accumulated ACK behaviour
- Consider TCP retransmit for timestamps and video decoding
- Differences in FLV and MP4 playout encoding
- Modelling of buffer depletion events (playing mode / 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

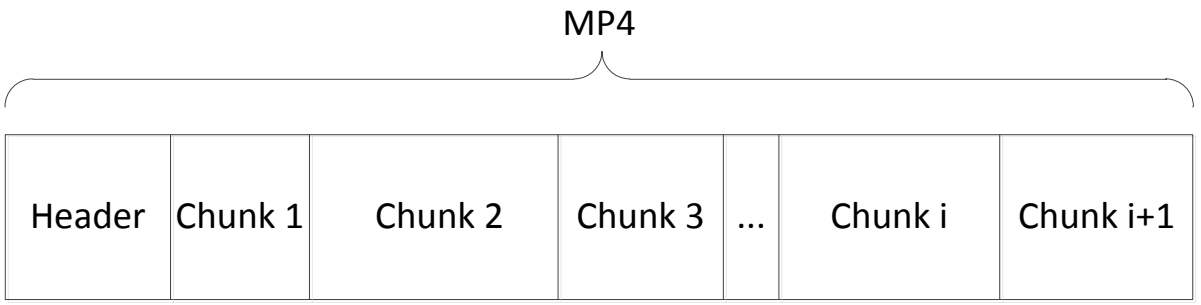
Observations (Throughput vs. Playout buffer Estimation):

- 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

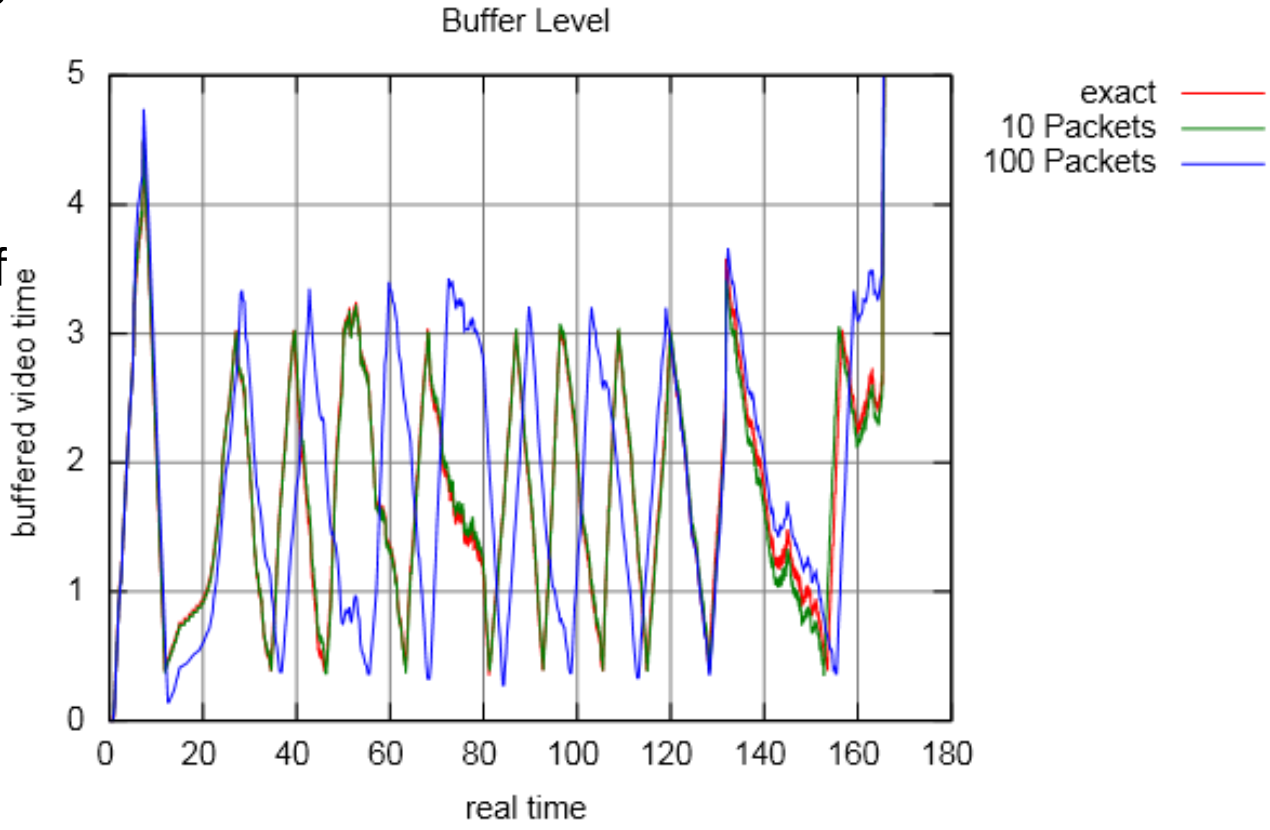


- Decoding of video header only
- Fill-level calculation based on extracted chunk sizes and the amount of observed data streamed
- Variable look-up interval → trade off of processing speed-up and accuracy

Estimation Method based on Throughput

Observations:

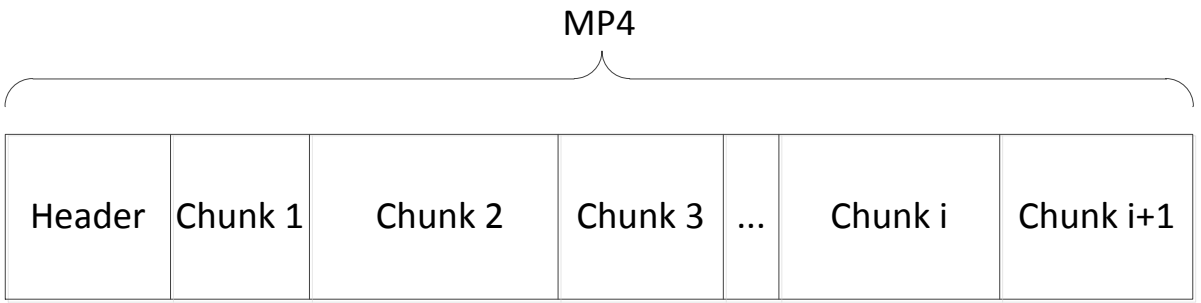
- Processing speed-up
- Loss in accuracy depending on the look-up interval
- Correct calculation of number of re-buffering events for small interval
- Immediate impairments in re-buffering time calculation



Combined Estimation Method

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)

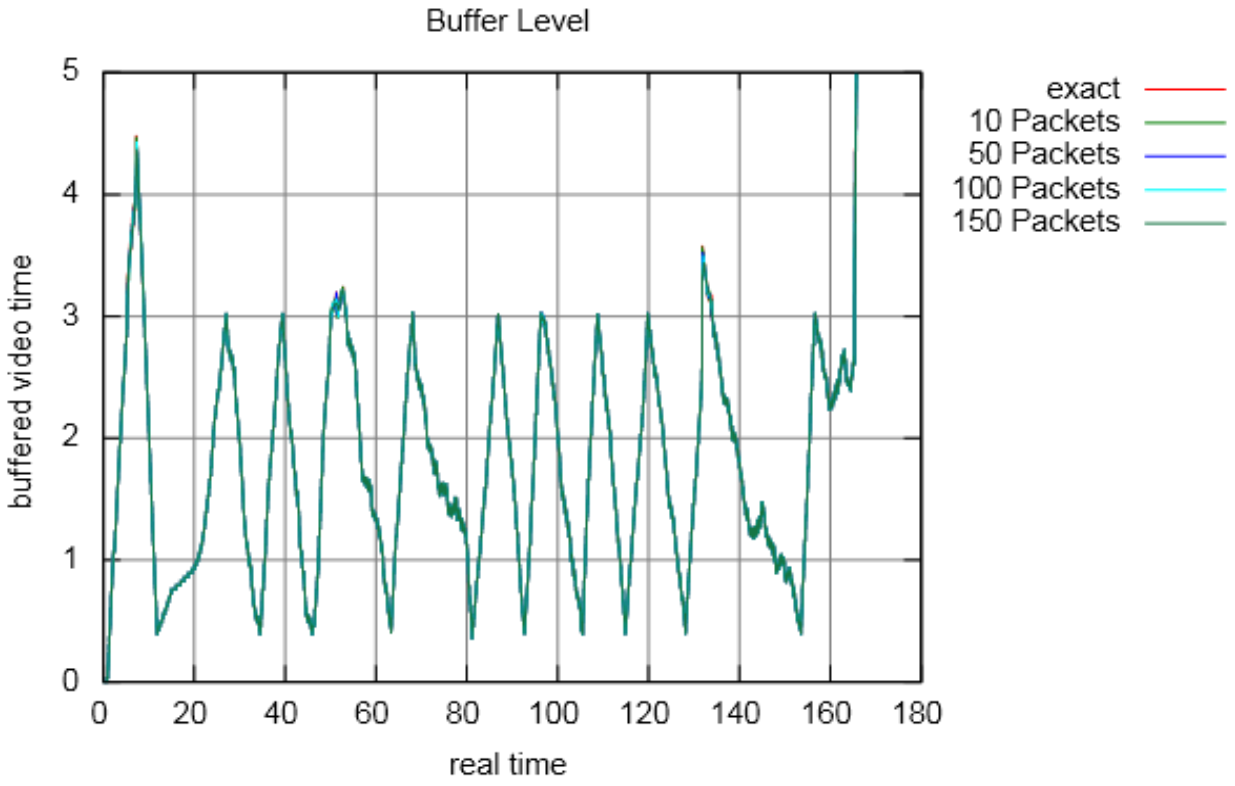


- In bad cases (buffer fill level below a certain value):
  - Estimation Method based on Video decoding
- Variable look-up interval

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



Adaptive Streaming

MPEG-DASH

- New standard for video adaptive streaming
- Specified in ISO/IEC23009-1
- Separation of stream generation and its distribution
- Video chunks with different location, bitrate, resolution or codec
  → original video stream is available in multiple versions
- Video chunk index (Media Presentation Description (MPD)) listing all available video versions per chunk for the client to select from

- Main advantage changing the video quality due to network parameters
- Video quality could get worse but stalls are prevented

Adaptive Streaming

MPEG-DASH

- MPD is the main index
- Shows all available presentations of a stream
- Stream representations with equal media content but different streaming behaviour are grouped in adaption sets
- Representations contain one or more segments delivered as single files
- Client can switch between representations

MPEG-DASH quality estimation

- MPD is needed for estimation
- MPD is built up as XML structure and can be identified by the text string “<MPD”
- Index list needs to be parsed for video segment file locations and byte ranges
- HTTP requests can be identified as parts of the video stream
- Two considered estimation methods

Adaptive Streaming

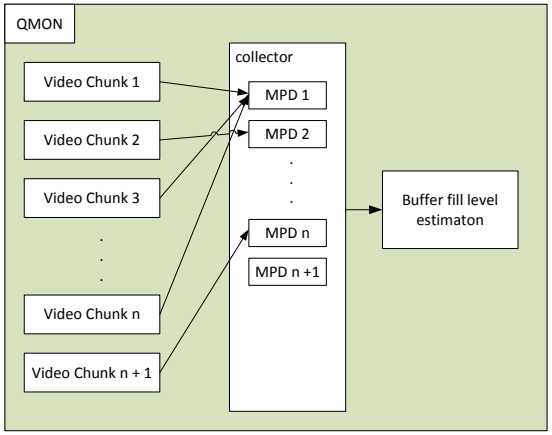
MPEG-DASH quality estimation

First method:

- Each packed must be passed to QMON
- Results have to be collected
- Overall stalling and re-buffering events have to be calculated

Second method:

- Each video segment considered as “whole video”
- Quality estimation for each “video”
- Entity on higher level which collects sub results and assigns them to the overall video stream



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 only as well as Combined Estimation Method:

- Same PCAP files have been used in all tests for comparison reasons
- Results were compared with user feedback protocols and with the results of the Estimation Method based on Video decoding
- Equally good match between user feedback protocols and calculated results

Evaluation

estimation interval stepping	processing time	# re-buffering events	re-buffering time
	Both algorithms - good case video		
human	-	0	0 s
every packet	6 s	0	0 s
10 packets	3 s	0	0 s
50 packets	3 s	0	0 s
100 packets	3 s	0	0 s
150 packets	3 s	0	0 s
250 packets	3 s	0	0 s
	Estimation Method based on Throughput - bad case video		
human	-	10	58 s
every packet	12 s	10	56,6 s
10 packets	6 s	10	56,0 s
50 packets	6 s	10	54,4 s
100 packets	6 s	10	53,7 s
150 packets	6 s	9	51,3 s
250 packets	5 s	6	49,1 s
	Combined Estimation Method - bad case video		
human	-	10	58 s
every packet	12 s	10	56,6 s
10 packets	8 s	10	56,6 s
50 packets	8 s	10	56,6 s
100 packets	8 s	10	56,6 s
150 packets	8 s	10	56,6 s
250 packets	7 s	10	56,6 s

Key Results and next Steps

- Measurements based on throughput leads to inaccurate results
- Network based Video quality 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 retains most of the gained speed up and fully retains the estimation accuracy at the same time

- Refinement of the video quality estimation → new codecs & adaptive streaming
- Considering other services such as social networks or web browsing in QMON