# A Network-based Method for Measurement of Internet Video Streaming Quality

**ITG-FG 5.2.3 - Next Generation Networks**

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## Outline

1. Motivation
2. Related Work
3. Measurement Procedure
4. Measurement Evaluation
5. Results





## Motivation

### *Video streaming influences the Internet*

- Video streaming services contribute a **major portion of today's Internet** traffic mix
- Increasing number of **video enhanced web pages**
- **Smart phones and USB sticks** cause a fast increase in video download usage in mobile networks
- Increased **network capacity** (e.g. **HSPA+**) enable **higher quality video** services

### *Video streaming measurement becomes vital*

- **Video network transport quality needs to meet the video play out quality requirements**
- But how do you know?
- **Measurement results** provide insight into the actually achieved quality
  → can be used **for network planning and traffic engineering**

**A Network-based Method for Measurement of Internet Video Streaming Quality**





## Related Work

### *Video quality measurement*

- Video quality in terms of delay, loss, jitter robustness
- Quality of Experience measurement still an area of research
- Unsolved problem of QoE estimation based on packet transport characteristics

### *Video quality estimation based on network throughput*

- Video streaming services can be **monitored by DPI devices** within the network, which provide **insight into round trip time**, **packet retransmission rate** and **network provided throughput**

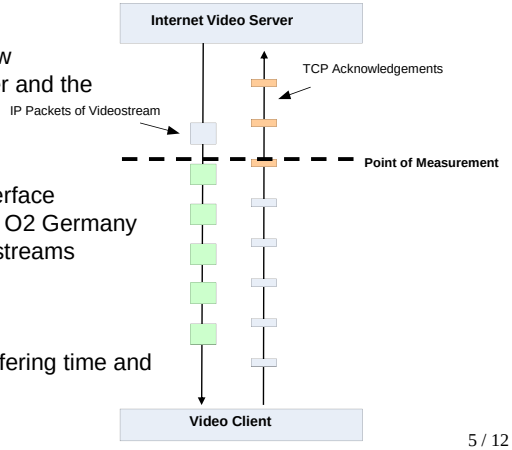
### *Video quality estimation based on play out buffer level*

- Most **precise QoE estimates** can be achieved by **end device play out buffer level** measurements.
- No video impairment is expected, if play out buffer depletion is avoided
- **Fill level thresholds** provide early warnings about **pending buffer depletion**

# Measurement Procedure

## *Network based Measurement*

- Platform and end device independent measurement
- Observation of video packet flow between the e.g. Youtube server and the watching/evaluating client
- Notebooks with HSPA-Sticks (up to 20Mbps)
- Point of Measurement at Gi-interface within the network of Telefonica O2 Germany
- PCAP traces of different video streams (360p … 1080p resolution) for offline processing
- User experience protocols for initial buffering time, total re-buffering time and number of re-buffering events





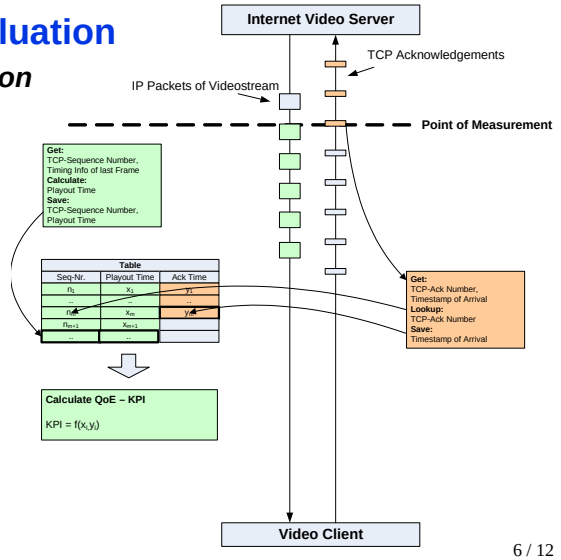





# Measurement Evaluation

## *Play out buffer estimation*

- PCAP trace processing
- Flow identification
- TCP segment and associated ACK tracking
- Video payload decoding ( .flv & .mp4 )
- Extraction of play out time and ACK timestamp
- Deduce play out buffer fill level as QoE KPI
- Special handling of buffer depletion events and re-buffering behaviour





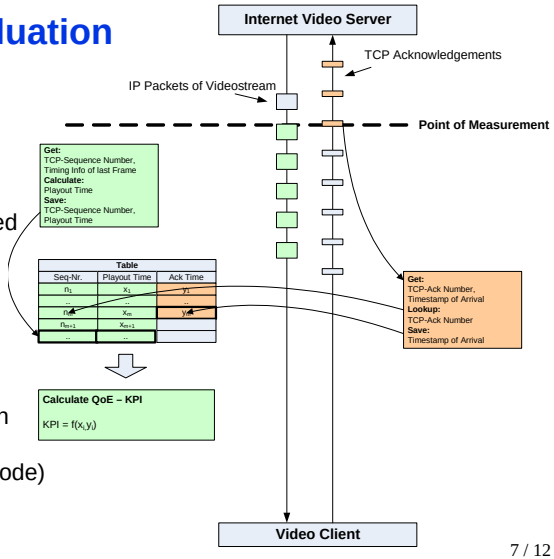





# Measurement Evaluation

## *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 play out encoding
- Modelling of buffer depletion events (playing mode / buffering mode)










# Results

## *Evaluation of Youtube video downloads*

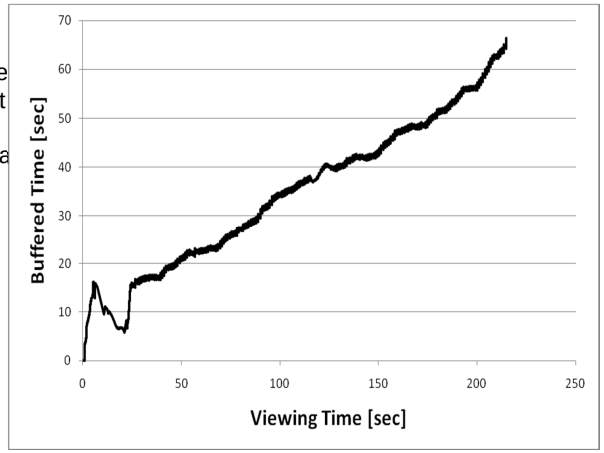
- Video resolution: 360p (typical), 480p, 720p (HD), 1080p (HD)
- Video encoding: Flash Video (.flv); increasingly MPEG4 (.mp4) (HD videos are mp4 encoded)
- Youtube's streaming behaviour varies over time (e.g. throttle parameter)

| Number | Resolution | Throughput required [kbps] | Playout Time [sec] | Container file format | Numer of tests | Number of test with re-buffering |
|---|---|---|---|---|---|---|
| 1 | 320x240 | 431 | 280 | flv | 3 | 0 |
| 2 | 480x320 | 515 | 357 | mp4 | 2 | 1 |
| 3 | 640x360 | 799 | 163 | flv | 1 | 0 |
| 4 | 854x480 | 1216 | 163 | flv | 2 | 0 |
| 5 | 854x480 | 1066 | 203 | flv | 1 | 0 |
| 6 | 450x360 | 845 | 221 | flv | 1 | 0 |
| 7 | 1280x720 | 2026 | 152 | mp4 | 3 | 1 |
| 8 | 1280x720 | 2893 | 236 | mp4 | 2 | 2 |
| 9 | 1280x720 | 2017 | 262 | mp4 | 2 | 0 |
| 10 | 1280x544 | 2103 | 135 | mp4 | 2 | 2 |
| 11 | 1920x1080 | 3567 | 235 | mp4 | 2 | 2 |
| 12 | 1920x1080 | 3427 | 262 | mp4 | 1 | 1 |
| 13 | 1920x1072 | 3644 | 254 | mp4 | 3 | 3 |

# Results

## *360p FLV video example*

- Steep initial buffering phase followed by a more moderate constant increase of buffered video data
- No depletion
- In conformance with recorded QoE





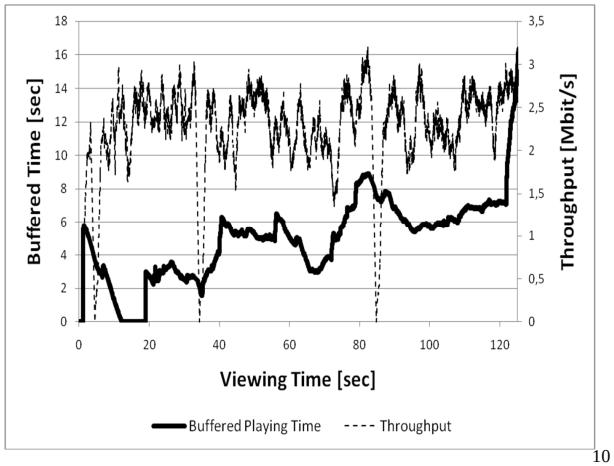





# Results

## *1080p MP4 video example*

- 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)





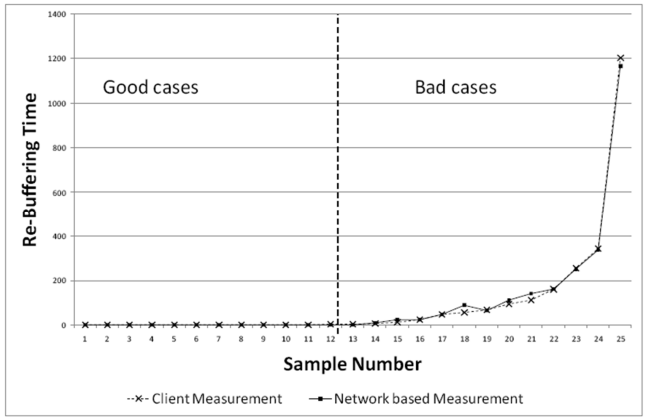





# Results

## *Comparison of re-buffering simulation and client experience*

- Comparison in terms of estimated outage time in seconds





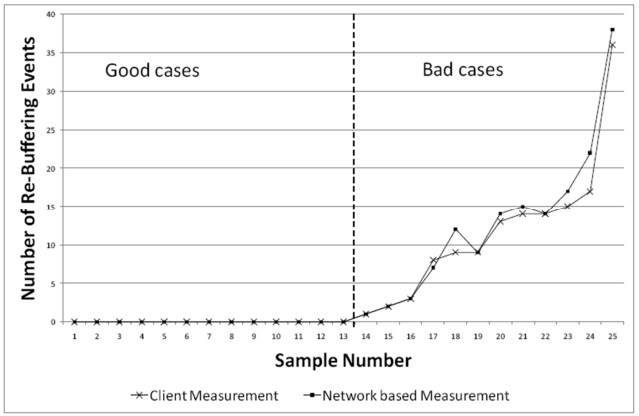





# Results

## *Comparison of re-buffering simulation and client experience*

- Comparison in terms of the estimated number of outage events



## Results

### *Throughput vs. Play out buffer based measurement*

- Throughput relevant information was extracted from the traces by access of header information or the use of common procedures:
  - total size of the video,
  - video play out time and
  - total time of transmission of the video file.
- Test 2: average required throughput of 2.1Mbit/s. → 2.28Mbit/s achieved
- 3 major throughput fluctuations observed; only one resulted in buffer depletion
- Accumulated throughput measurement could get close to play out buffer based measurement precision

### *Conclusion*

- Detailed network based play out buffer measurement provides reliable QoE estimates.
- More detailed investigations whether the increased effort compared to average throughput measurements really pays off.



# Thank you

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