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

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# Motivation

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## **Video streaming measurement becomes vital**

- Video network transport quality needs to meet the video playout quality requirements (QoS  $\leftrightarrow$  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

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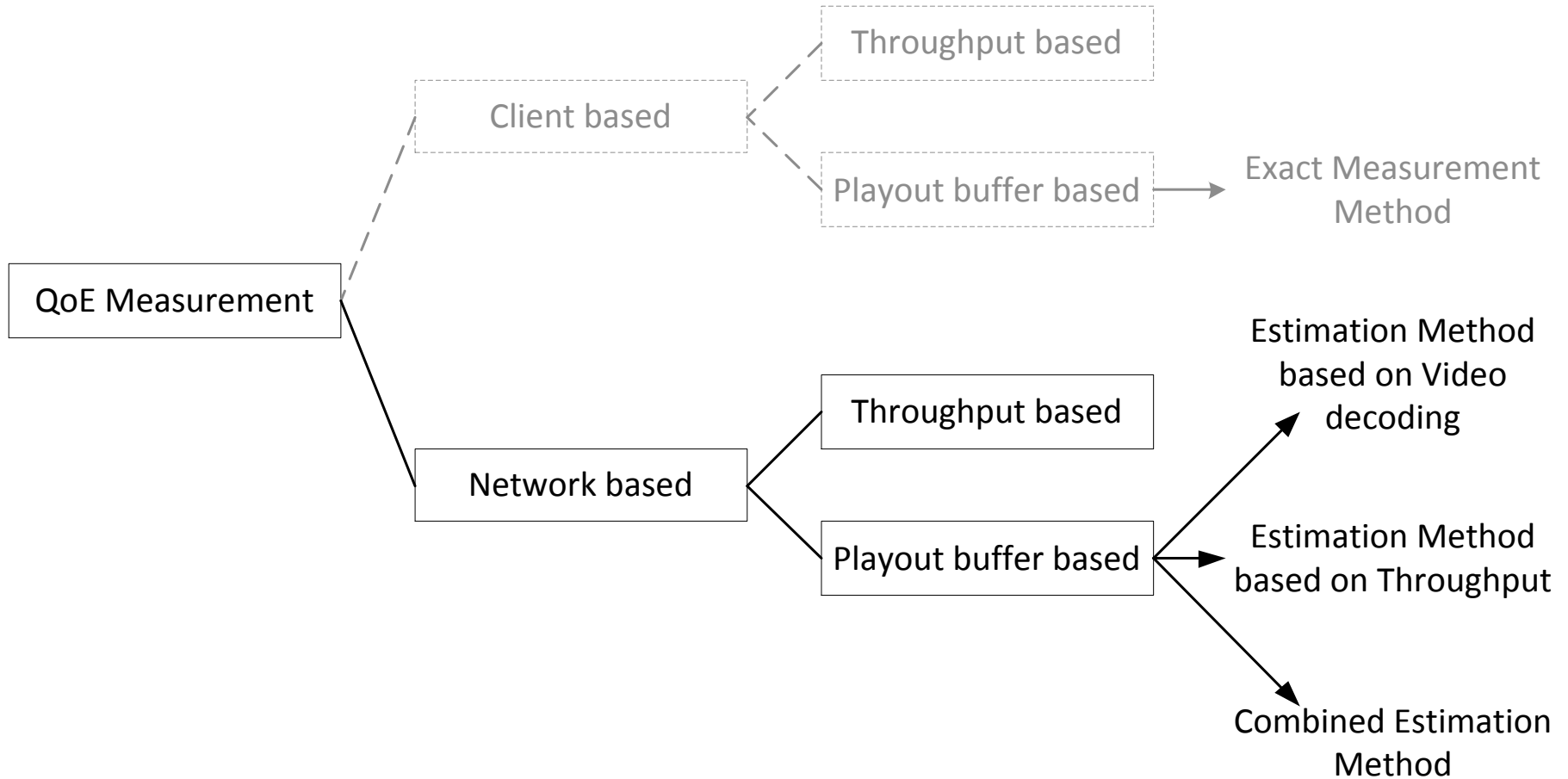
## **Minor KPI:**

- 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

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

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

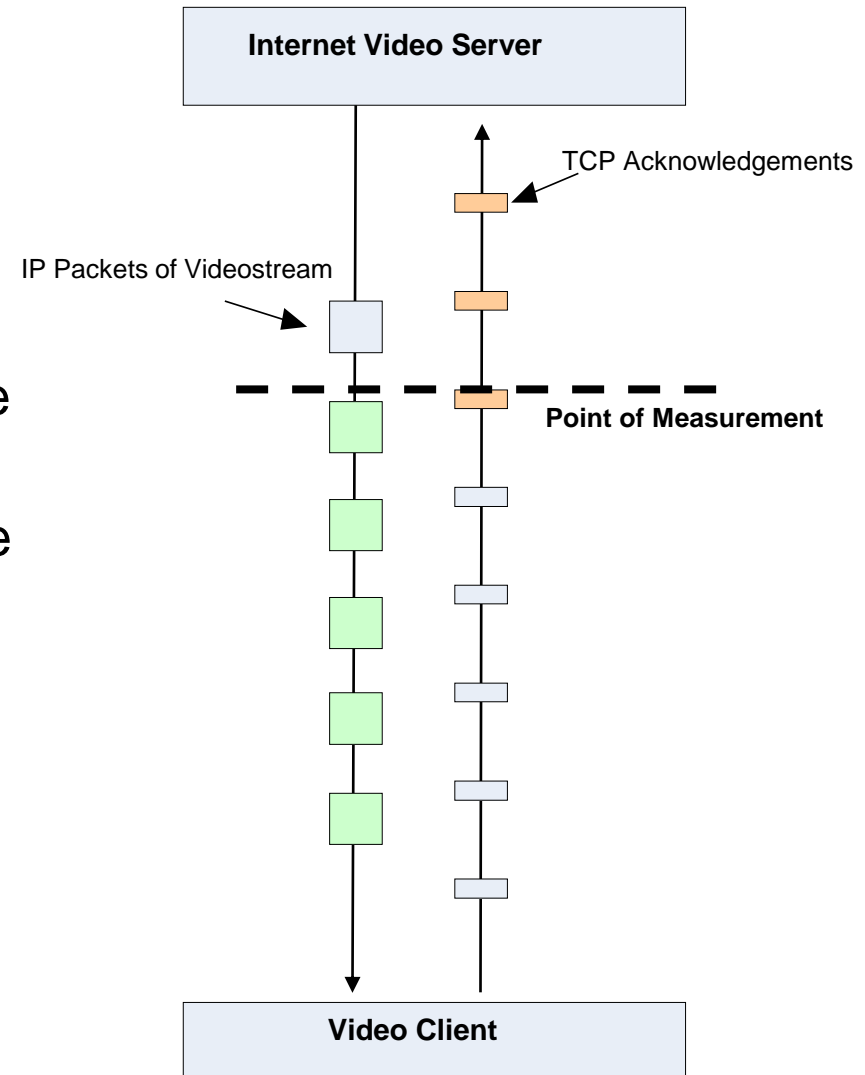
## **Video quality measurement based on playout buffer level**

- 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:

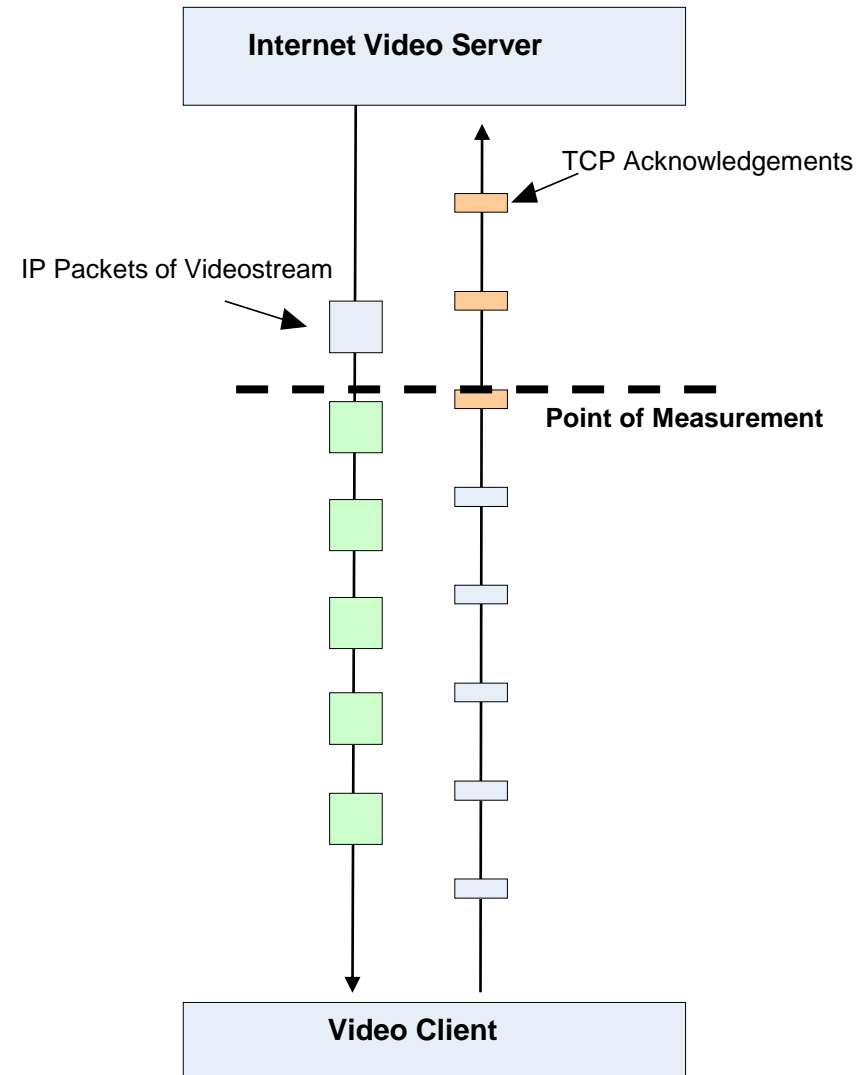
- Platform and end device independent estimation
- Observation of video packet flow between the YouTube server and the watching/evaluating client
- Point of Measurement at Gi-interface
- PCAP traces of different video streams (360p ... 1080p resolution) for offline processing (TCP Acks)



# 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)

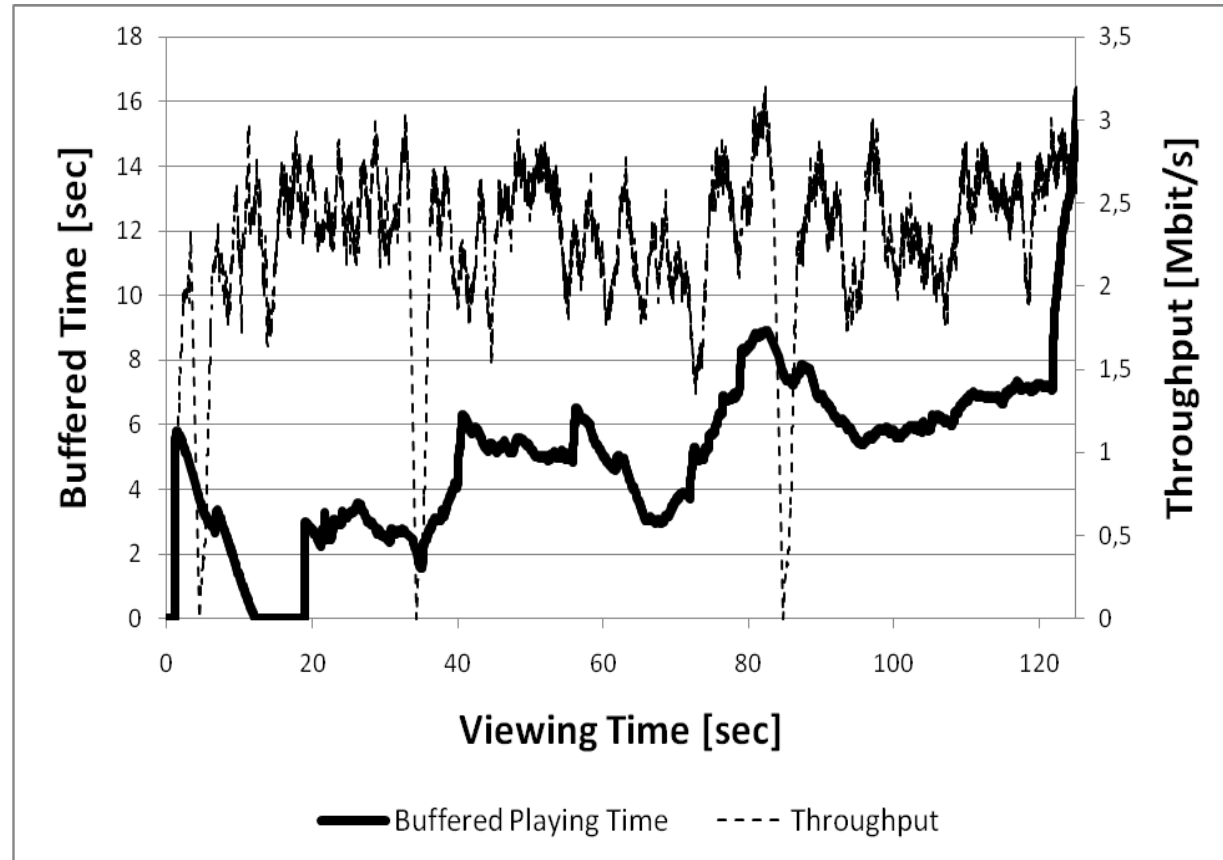




# Estimation Method based on Video decoding

## 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

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## **Observations (Throughput vs. Playout buffer Estimation):**

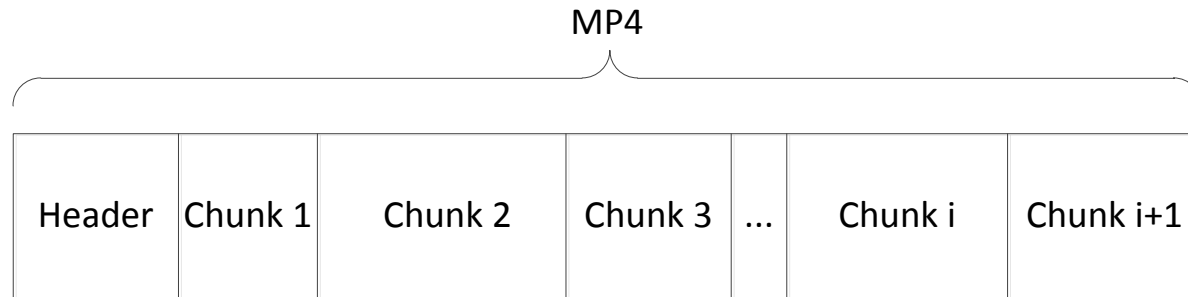
- Throughput relevant information was extracted from the traces by header information decoding or the simple packet statistic:
  - total size of the video
  - video playout time
  - total time of transmission of the video file
- Test: average required throughput of 2.1Mbit/s. → 2.28Mbit/s achieved
- 3 major throughput fluctuations observed; only one resulted in buffer depletion

# Estimation Method based on Throughput

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## 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

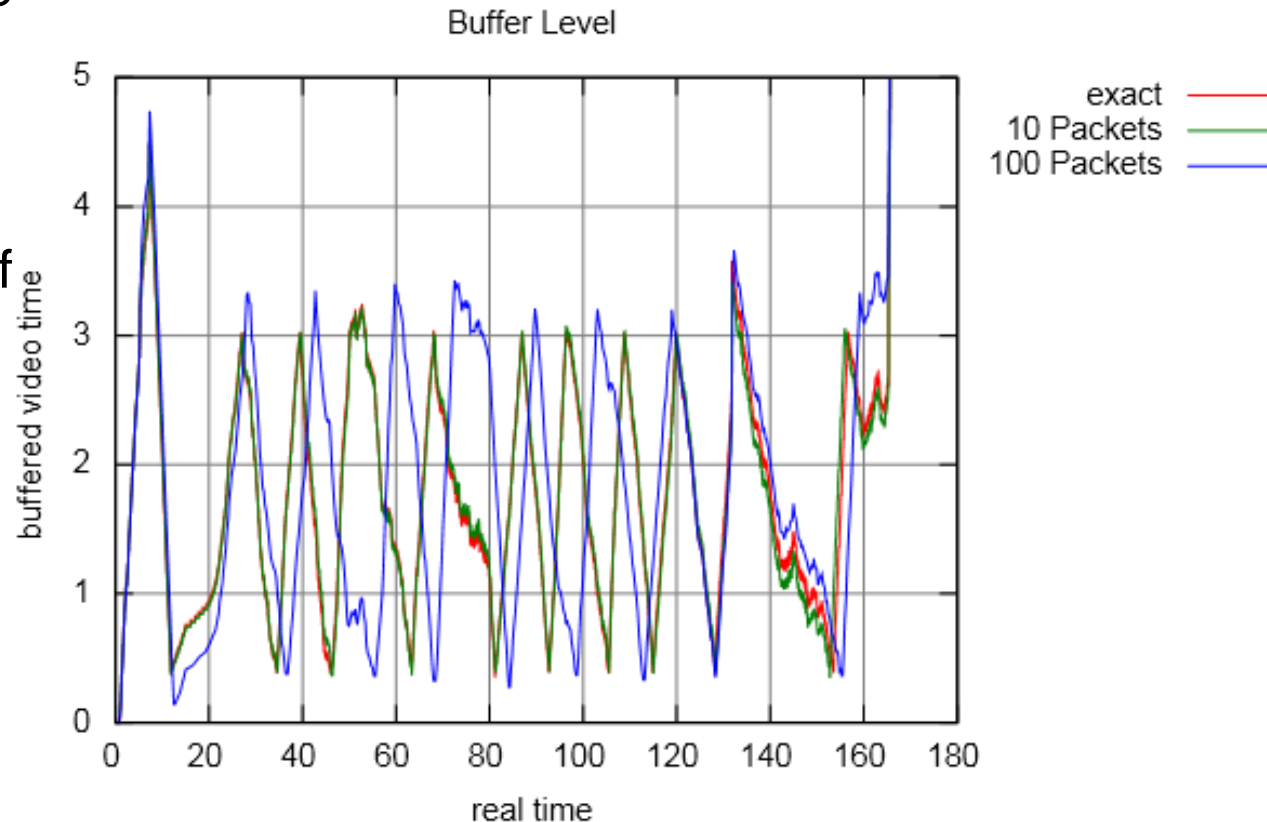


- Decoding of video header only
- Fill-level calculation based on extracted chunk sizes and the amount of observed data streamed
- Variable look-up interval → trade off of processing speed-up and accuracy

# 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

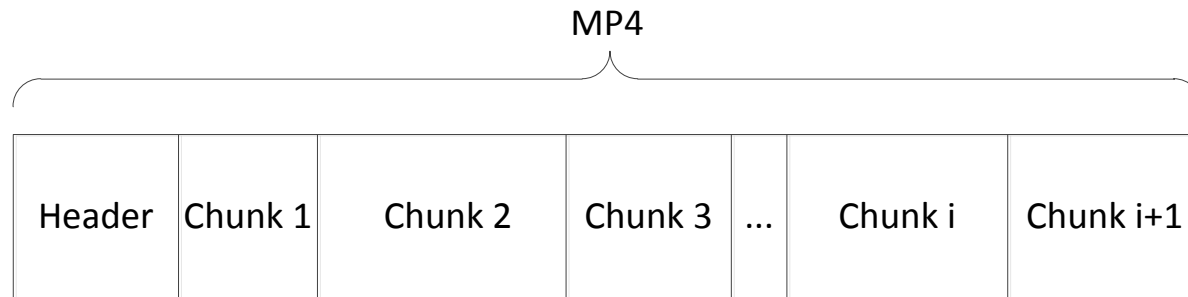


# Combined Estimation Method

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## 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)

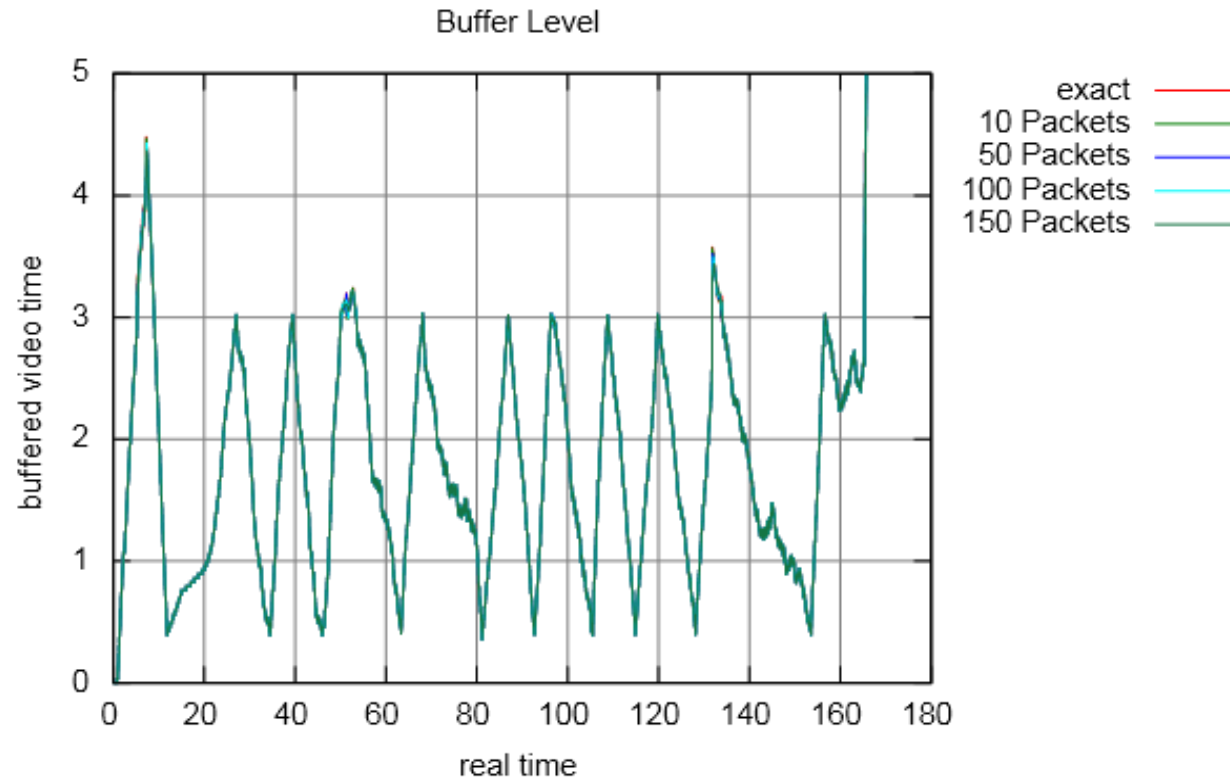


- In bad cases (buffer fill level below a certain value):
  - Estimation Method based on Video decoding
- Variable look-up interval

# 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

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## **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

estimation interval stepping	processing time	# re-buffering events	re-buffering time
<b>Both algorithms - good case video</b>			
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
<b>Estimation Method based on Throughput - bad case video</b>			
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
<b>Combined Estimation Method - bad case video</b>			
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

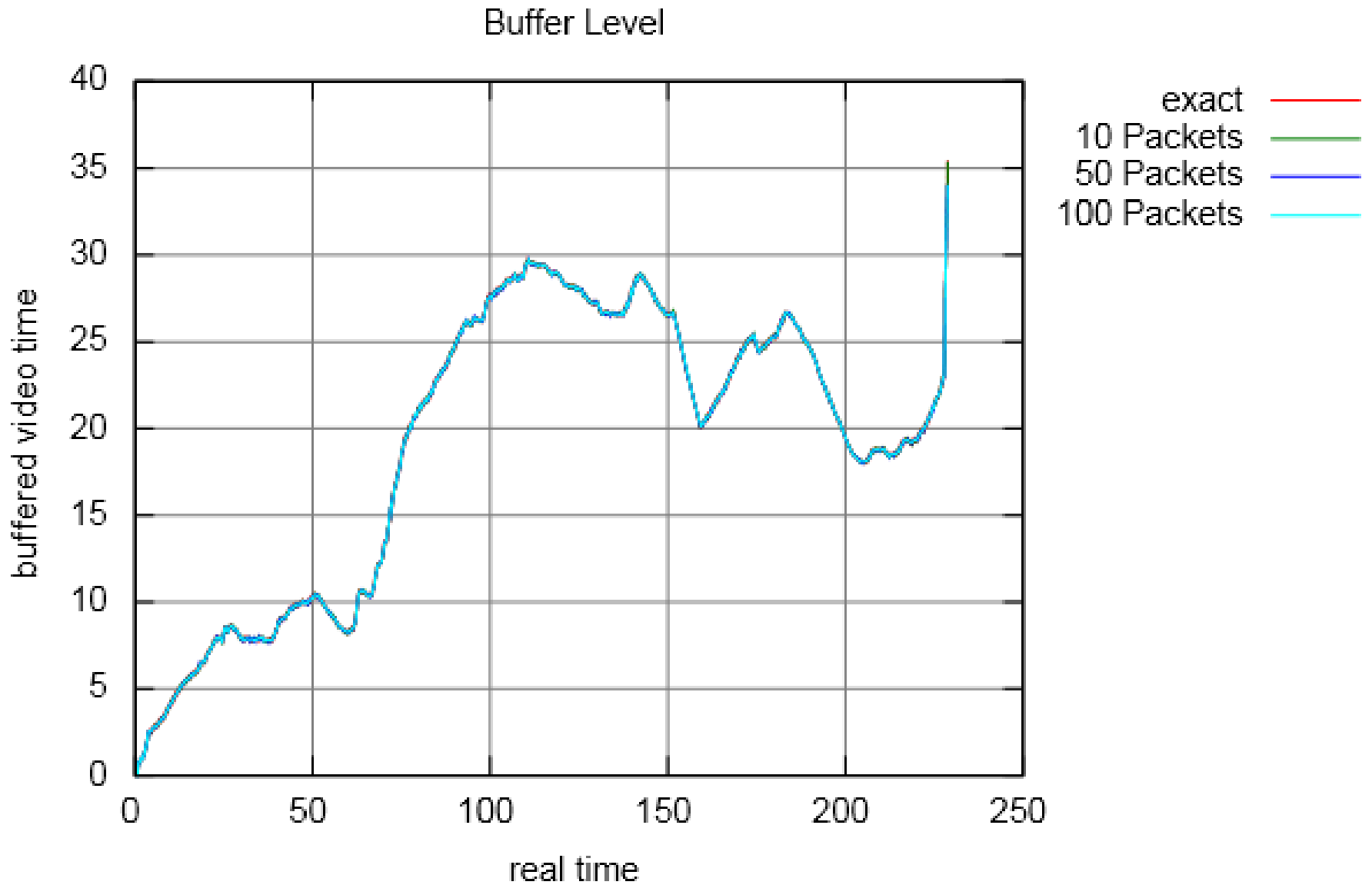
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- Measurements based on throughput leads to inaccurate results
- Network based Video QoE estimation leads to valid and accurate outcomes with both of our methods
- Estimation based on Throughput combined with header extraction speeds up the processing 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

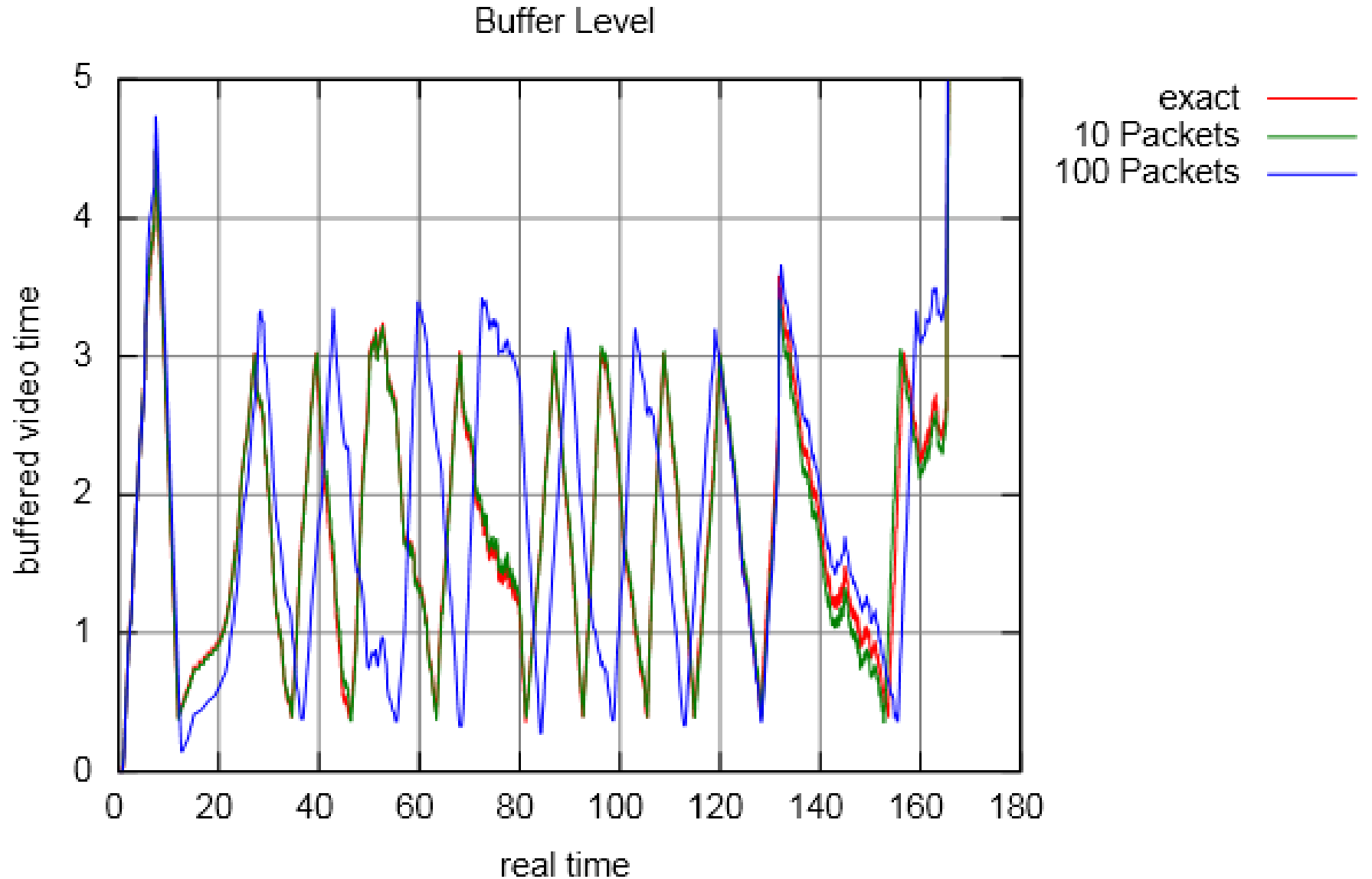
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# Backup

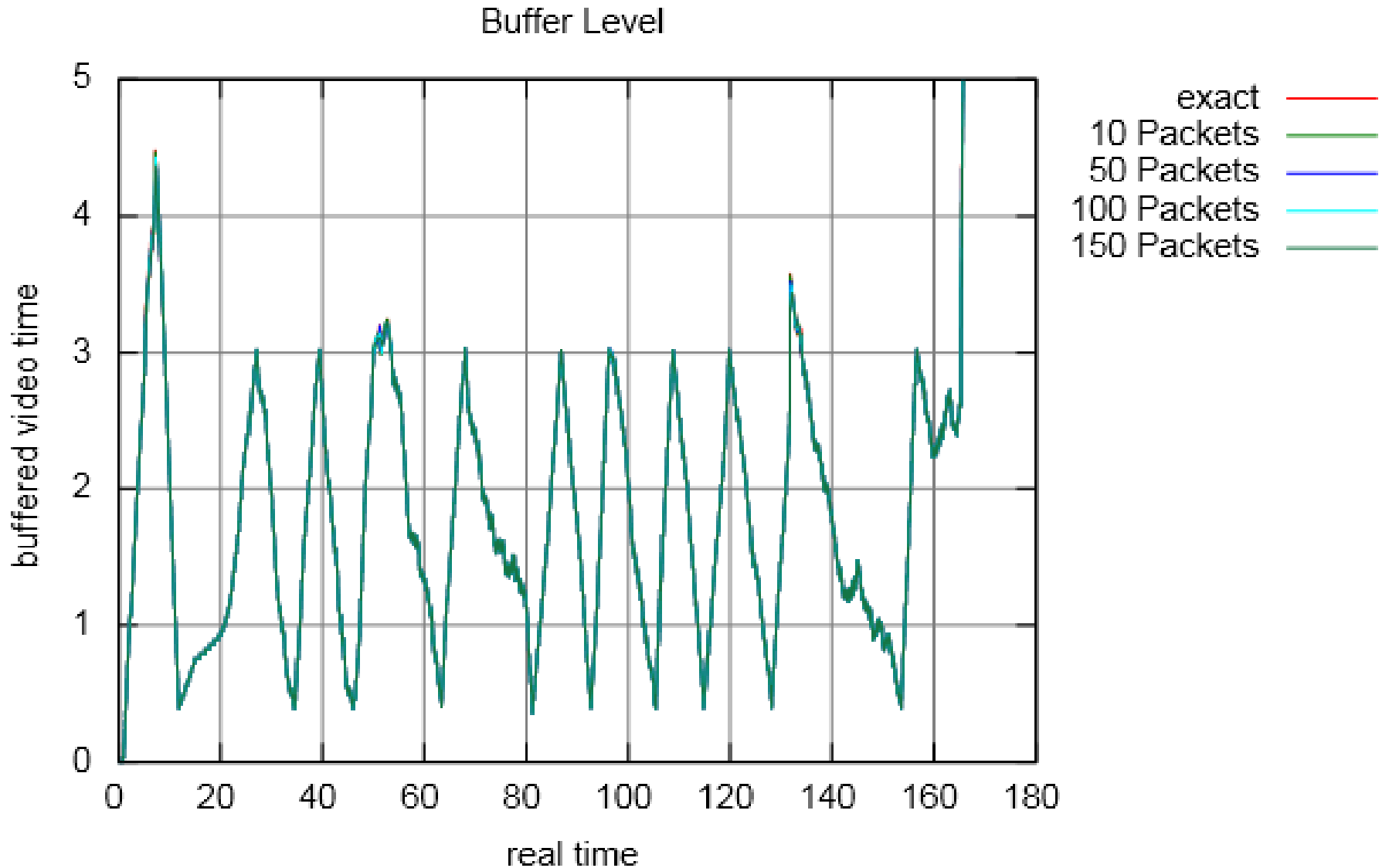
# Comparison of the Methods



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# Classification of Video QoE Measurement Methods

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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