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

Marcus Eckert
Chair of Communication Networks
Chemnitz University of Technology
Chemnitz, Germany
marcus.eckert@etit.tu-chemnitz.de

Thomas M. Knoll
Chair of Communication Networks
Chemnitz University of Technology
Chemnitz, Germany
knoll@etit.tu-chemnitz.de

Introduction

Video streaming services, such as YouTube, are responsible for a major part of the transmitted data volume in the Internet and it is expected, that they also will strongly affect mobile networks. Streaming video quality mainly depends on the sustainable throughput achieved during transmission. In order to achieve an acceptable video quality in mobile networks (with limited capacity resources), traffic engineering mechanisms have to be applied. For that, the streaming video quality needs to be measured and monitored permanently. In this paper we propose an advanced method for YouTube video QoE estimation that works purely network based. This allows for transparent monitoring without the requirement to install any monitoring tools on the users' end devices or on the server platform. Compared to already existing network based QoE estimation algorithms our advanced method achieves a better monitoring performance with less processing effort and negligible loss in accuracy.

Network-based QoE Measurement

Instead of fine grained pixel error and block structure errors the algorithm presented is focusing on video stalling events and their re-buffering timings as quality metric for the experienced QoE. To determine the number and duration of re-buffering events it is necessary to comprehend the fill level of the play out buffer at the client. Focusing on YouTube video incurs TCP encoded HTTP streaming transport. Our method performs the QoE estimation based on the measured TCP segments of the video stream at the observation point. In the following we describe 3 variants of our method - an exact method, an estimation method and a combination of these.

For all methods the following steps have to be carried out in advance: (1) the video flow needs to be identified within the traffic mix, and (2) the TCP segment information and the TCP payloads of the video flow have to be extracted.

A. Exact Method

The actual play out time is extracted from the decoded video and compared with the timestamp of the respective TCP segment. Out of this comparison the fill level of the play out buffer can be estimated. This includes the processing of the initial buffering phase, the stalling detection by buffer depletion events as well as the correct calculation of re-buffering times.

B. Estimation Method

The estimation method is a variation of the exact method aiming for a better processing performance. The idea is to decode the header of the streamed video only. The collected video information in the header includes the respective size and duration information of all subparts (chunks). The estimation algorithm calculates the fill-level based on those chunk sizes and the observed amount of data streamed. This calculation yields the number and duration of re-buffering events. Note, that there is a trade-off between processing speed-up and accuracy.

C. Combination of the two Methods

The last variant of the algorithm tries to combine the gained speed-up of the second variant with the accuracy of the exact algorithm. This is obtained by dynamically adopting the processing mode (exact mode/estimated mode) to the experienced throughput. The adoption is based on a single threshold value of the buffer fill-level: the exact method is used only if the buffer fill-level is below the threshold.

Note, that the precision of all 3 algorithms can be further improved by using the timestamp of the ACKs instead of the timestamp of the TCP data segments for the buffer fill-level calculation.

Method of Evaluation

In order to evaluate the QoE estimation algorithms we compared the video QoE estimated by a group of test persons to the outcome of the algorithms. During the test, a set of 17 YouTube videos (with all available resolutions) were watched on laptops with 3G network access. During the assessment every re-buffering event and the overall buffering time for each video had been recorded and documented by the test persons. Concurrently the traffic was monitored at the sGI Interface within the Operator's network. For later processing the traffic traces were saved in PCAP file format.

Each QoE estimation algorithm variant was fed with the same monitored (packet level) traffic traces and the resulting QoE estimates were with the observations of the test persons. In the next chapter an overview of the evaluation results is provided.

RESULTS

Table 1 shows the number of re-buffering events and the re-buffering time determined by the test persons, by the exact algorithm, by the estimation algorithm and by the combined algorithm. No differences are observed for "good case videos" (videos without stalling): all three algorithms detect no stalls but the estimation method and the combined method require less than half of processing time. For "bad case videos", the exact algorithm and the combined algorithm match well to the human observations. However, the accuracy of the estimation algorithm significantly drops with increasing estimation interval steppings. Hence, the combined algorithm seems to be a good compromise between processing speed-up and accuracy.

estimation interval stepping	processing time	# re-buffering events	re-buffering time
Both algorithms - good case video			
Human	-	0	0 s
Exact	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 algorithm - bad case video			
human	-	10	58 s
exact	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 algorithm - bad case video			
human	-	10	58 s
exact	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

Table 1: Comparison of QoE estimation results

Figure 1 and **Figure 2** show the comparison of the buffer fill-level calculated with the exact and the combined algorithm. **Figure 1** is based on a "good case video", **Figure 2** on a "bad case video". One important observation is that the results of the combined method are matching to those of the exact method.

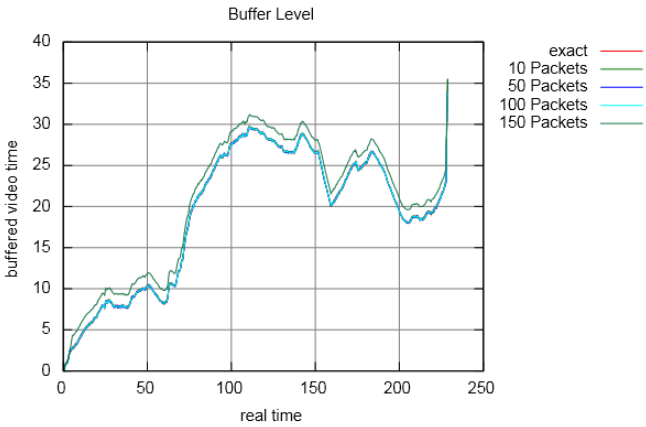

Figure 1: Buffer fill level estimation - good case video

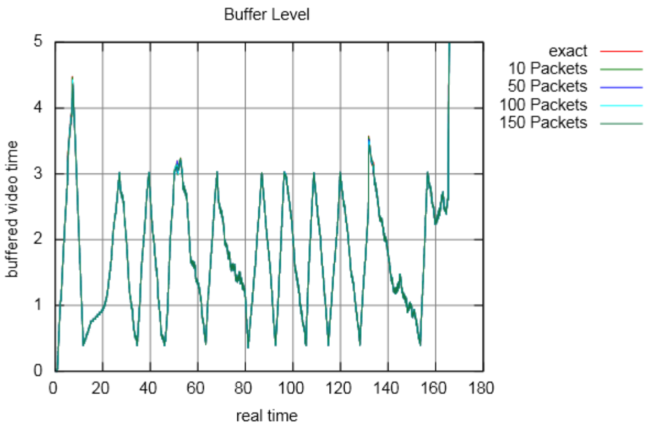

Figure 2: Buffer fill level estimation - bad case video

SUMMARY

The presented work on QoE measurement for YouTube video streaming has proven that automated network based QoE estimation is feasible and produces accurate results. The exact calculation method leads to meaningful results wrt. the number and time of re-buffering events. The estimation method shows a better performance in terms of processing time but is less accurate. To achieve exact results with less processing time the combined algorithm has been proposed. Further online measurements will be undertaken to consolidate the findings and to deliver a production ready monitoring solution.

ACKNOWLEGMENT

This work is carried out within the CELTIC MEVICO project funded by the Federal Ministry of Education and Research (BMBF) of Germany (grant 01BU1013).

II. REFERENCES

[1] S. Rugel, T.M. Knoll, T. Bauschert, M. Eckert: A Network-based Method for Measurment of Internet Video Streaming Quality, ETS 2011 Poznan