QoE Monitoring (QMON) Demo Proposal

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I. INTRODUCTION

Video streaming services, such as YouTube comprise a major part of today's Internet traffic. Mobile operators are highly interested to monitor the video streaming quality achieved in their networks as the customer satisfaction is very sensitive to it. There need to be mechanisms, which are able to observe the video streams and estimate the experienced quality. There are already some client based QoE approaches available, e.g. the YoMo approach [1]. However, such client based solutions are not feasible because of the needed access to the end device.

The QMON approach outlined in this paper describes a network based instead of a client based solution. Some other monitoring solutions follow a similar way of estimation, like the "Passive YouTube QoE Monitoring for ISPs" [2]. However, they are not supporting such a wide range of video encodings as well as container formats.

QMON enables transparent video monitoring within the operator's network without requiring end device support. In combination with a traffic enforcement algorithm, which is currently under development, it will also be possible to improve the QoE of transmitted video streams. Therefore the video quality estimation is a vital input for the QoE control loop. The flow detection which is required for the monitoring can either be realized by static definition or by dynamic triggering by means of a DPI device.

QMON currently allows the dectection and QoE monitoring of YouTube video streams in MP4, "Flash Video (FLV)" and WebM format both in "Standard Definition (SD)" and "High Definition (HD)" resolution.

II. FLOW DETECTION AND CLASSIFICATION

Before the QoE of a data stream could be estimated the stream has to be identified within the traffic mix. In the QMON demo two variants for flow identification and classification are realized. On the one hand the classification can be performed by an external Deep Packet Inspection (DPI) device, e.g. a Sandvine DPI device [3]. On the other hand it is possible to use a minimalistic DPI algorithm which is included in the estimation method. But for the built-in DPI variant there are a lot of restrictions, e.g. the traffic has to be unencrypted and the typical traffic patterns have to be known. Therefore, in our demo implementation the build-in detection algorithm is limited to YouTube video streams which comprise unencrypted TCP traffic.

III. NETWORK-BASED QOE ESTIMATION

Most video QoE monitoring solutions are focusing on fine grained pixel error and block structure errors. However such Key Performance Indicators (KPIs) are not suitable for YouTube video streams, since YouTube is using the so called pseudo streaming that downloads the video file in a play out buffer and plays it from there. Therefore, pixel errors due to bad QoS parameters don't occur. The main reason for a bad QoE of YouTube videos are stalling events. For that QMON focuses on the occurrence and duration of playback stalls. To determine these events it is necessary to estimate the fill level of the play out buffer and to detect depletion events. Due to the fact that QMON does not have access to the user's end device, it relies on the data which could be observed at a measurement point within the network. The required information needs to be extracted out of TCP since YouTube is based on TCP transport. Therefore, the TCP segment information and the TCP payloads of the video flow have to be analysed.

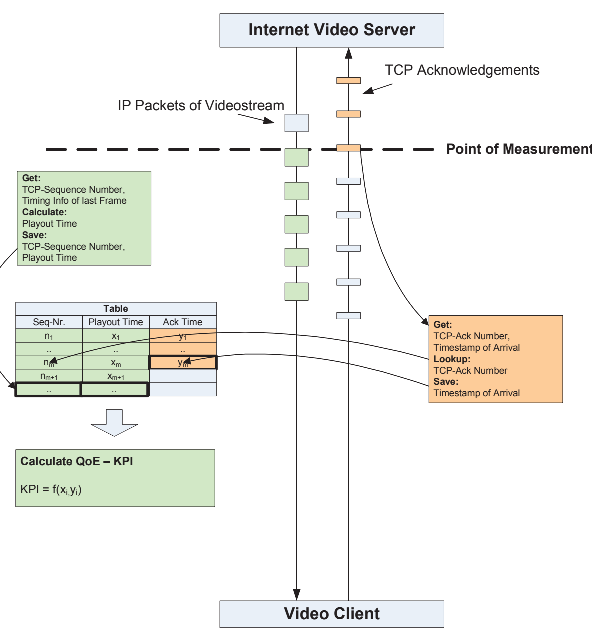

Figure 1: QoE estimation scheme [4]

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The video timestamps which are encoded within the payload are extracted. For that it is necessary to decode the video within the payload. After deriving the play out time it is compared to the timestamp of the respective TCP segment. The estimation process is shown in **Figure 1**. The result of this comparison is an estimate of the fill level of the play out buffer within the client. This estimation is done without access to the end device.

IV. Demonstrator

To prove the functionality of our estimation method a demonstrator was built up in different steps. The first version is only capable of processing offline PCAP traces of recorded traffic. The actual demonstrator is also capable of performing online measurements within the network. The setup of the YouTube demonstrator is shown in **Figure 2**. It consists of two laptops. One of them provides the uplink to the Internet and also hosts the estimation tool and the simplified build-in DPI function. The second laptop has its Internet connection provided by the first one. The first laptop can therefore observe the whole data traffic which is transferred to the second laptop.

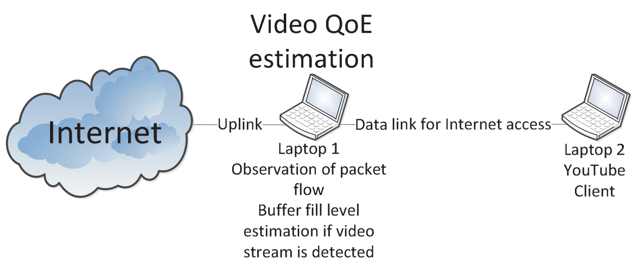

Figure 2: YouTube video QoE demonstrator setup

As soon as a video stream is detected by laptop 1 the estimation algorithm saves the characteristics of the TCP session as 5-tuple. The 5-tuple consists of the protocol type, the source and destination IP addresses as well as the source and destination port. In a next step, each packed which fits to the 5-tuple is observed and the payload is decoded. As soon as a play out timestamp is extracted, the algorithm calculates the actual buffer fill level considering the occurrence and duration of stalling events. For the demonstration the estimated buffer fill level of laptop 2 is displayed as a diagram on laptop 1. The diagram is updated for each received TCP segment of the observed data flow.

V. Method of Evaluation

A group of test persons had been involved in the evaluation of the estimation method and the demonstrator. A test consisting of 17 YouTube videos (in all available resolutions) was set up. The videos were watched on laptops with 3G mobile network access and the data traffic was recorded at the Gi interface within the mobile operator's network. During the assessment the users had to note down the occurrence of stalling events as well as their duration. Later the recorded PCAP traces were processed with the offline estimation tool.

VI. Results

The number of re-buffering events and the re-buffering time determined by the test persons show a nearly 100% fit for so called "good case videos" (videos without stalling). For "bad case videos" the number of stalling events had been detected with a high accuracy, too. Slight differences regarding the stalling time estimation exist compared to the human observations. Further experiments have shown that the accuracy can be increased if the timestamps of the acknowledgments are used for the calculation. This is because then the packet loss between the measurement point and the client is incorporated.

VII. Summary

The presented work on QoE measurement for YouTube video streaming is focusing on the occurrence of stalling events and their duration during the video playback instead of tracking the fine grained block structure and pixel errors. Furthermore, it has been proven that automated QoE estimation is feasible and yields accurate results even if the measurement is performed within the operator's network instead of at the user's end device.

The presented demonstrator shows the functionality of the estimation algorithm and has been evaluated for offline as well as online processing.

Acknowlegment

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