Investigating the Impact of Advertisement Banners and Clips on Video QoE

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***Abstract*—Although Quality of Experience (QoE) of Internet services can be affected by context influence factors, their actual impact is not widely investigated yet. In the context of online video services, web portals often display advertisement banners or clips to monetize their service. However, these advertisements can distract or annoy the users, which might degrade the QoE of the actual video service. In this work, two crowdsourcing studies were conducted to investigate the impact of advertisement banners and clips on video QoE. Therefore, both theoretical opinions on in-service advertisements and subjective quality ratings are evaluated. The findings confirm that advertisements are negatively perceived by users during service consumption, but a generally negative impact on video QoE cannot be supported, as the interplay of advertisement and the QoE of video services is rather complex.**

I. Introduction

Video is one of the most popular Internet services today, and it involves many stakeholders. Content creators produce videos, which are offered on video portals, and streamed through the networks of Internet service providers to end users. Thereby, all stakeholders strive to achieve a high perceived quality for the customers of the video service, which can be described by the concept of Quality of Experience (QoE) [1]. It has been shown that QoE is affected by technical parameters of the video streaming system, e.g., page load time of the video portal web site [2], or video encoding, initial delay, stalling, and adaptation of the HTTP adaptive video streaming (HAS) [3]. Additionally, human and context factors might influence the QoE [1], which have not been widely investigated yet.

Most video portals generate revenue from displaying advertisements (ads) on the video web site. This started with advertisement banners, i.e., static or animated images with advertisement content, and nowadays also includes advertisement video clips, which can be played back before (pre-roll), during (mid-roll), or after (post-roll) the actual content video. Thus, advertisements coexist and can influence the perceived Quality of Experience of the video service, e.g., by increasing waiting times for the video content or distracting the user from the content consumption. After finding that the ad load itself can have a significant impact on how long a user consumes video services and whether they return for more, several video service providers still experiment with the ad load [4]. Nevertheless, in the USA in the first quarter of 2017, full-episodes of premium video content averaged around four ads per mid-roll break and 97 s in total duration, and users saw about one pre-roll advertisement for every two video clips (duration less than 5 min) started.

This work investigates the context factor *advertisements* and its impact on video QoE. Therefore, two crowdsourced studies have been conducted on the impact of the encoding bit rate on the QoE of H.264 videos, which included implicit test conditions for advertisements. The first study displayed different advertisement banners on the video page and results of this study were already published as a part of our previous experiment described in [5]. The second study then builds on the previous study by incorporating pre-roll and mid-roll advertisement clips in the video quality test. Note that post-roll advertisement clips were omitted from this study, as they are less relevant when users browse videos and do not watch clips until the end [6]. While the actual QoE results for the video quality are of little importance, the impact of the different displayed advertisements on the QoE ratings will be evaluated. Additionally, the participants of the second study were asked theoretical questions on in-service advertisements, and their opinions will be presented to complement the actual QoE ratings.

Therefore, the work is structured as follows. Related works on video QoE and online advertisement are outlined in Section II. The two crowdsourced QoE studies are described in Section III. Section IV presents the results of the studies, and Section V discusses the results and concludes.

II. Related Work

The QoE of video services is influenced by many factors. These include parameters of the encoded video sequence itself (e.g. video bit rate, resolution, video encoding algorithm) [7] and technical parameters of the streaming, such as initial delay, stalling, or adaptation [3]. Also context factors can have an impact on the QoE [1]. Technical context factors, which describe technical interactions with the video streaming system, include device characteristics, service presentation,

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user interfaces, or coexisting services. On video portals, there are waiting times during the page load [2] or the design of the web page itself [5]. Additionally, streaming portals include advertisement banners or clips to monetize their streaming service. These advertisements can increase the waiting times or distract the user from the actual video.

Authors of [8] researched the effectiveness of contextual advertisements with web site banners. They found that the relevance of ads to the content and the complexity of banners have to be taken into account for effective advertisements. Annoying or busy advertisements might prevent users from processing and remembering the brand. However, the effect on content consumption and video perception or QoE was not studied.

A first study on the effect of advertisement clips in video streaming on the QoE was presented in [9]. The authors investigated the position, length, and transition of the ad clip in the streamed video sequence. Thereby, mid-roll clips were found to have the most negative impact on the MOS, but also a longer duration of the advertisement resulted in lower MOS. Their experiment was conducted in a controlled environment of a computer lab and the demography of the participants was limited to students and staff of the university. The research published in [10] investigated pre-roll advertisements before one main video content. They found that intrusive advertisements negatively affected attitudes and intentions towards both the advertised brand and the host web site, and were associated with higher rates of abandonment by the viewer. However, informative and humorous video advertisements and longer advertisements were perceived as less intrusive. This confirmed the findings of [11] that negative feelings and behaviors can result if consumers feel that an advertisement is intrusive and is being forced upon them. In [12], the authors investigated effects of ad length, ad position, and ad-context relevance on brand name recognition. They found that mid-roll ads interrupt the online viewing experience and can lead to better brand name recognition than pre-roll and post-roll ads because of attention spillover. However, mid-roll ads are useless when the ad is unrelated to the video content, because users are more likely to experience irrelevant information as annoying.

III. Study Description

Two crowdsourcing studies were conducted similar to [13], in which the users had to rate the QoE of three different H.264 video sequences with randomly selected quality level, i.e., high, medium, or low visual quality. Note that the explicit task of the users was to rate the QoE of the video sequences and they were unaware that the test conditions were actually related to advertisements.

The test sequences were prepared, such that the quality levels could be easily distinguished. Each video content was encoded with three different bitrates to produce video sequences at comparable video qualities. As the specific bitrate values were dependent on the content, the bitrate levels are further denoted as *high* (H), *medium* (M) and *low* (L). Both objectively measured quality using PSNR and a screening with expert viewers showed that the different quality levels are easy to distinguish. The sequences were encoded using the *x264*[1] implementation of the H.264 video coding standard. The resolution of sequences was adjusted to 576p in case of the advertisement banner study, and to 720p for the advertisement clip study. Furthermore, test sequences used for the advertisement clips study contained an audio track. The quality and volume of the audio track was constant for all the test sequences (including advertisement clips) in order not to possibly influence the QoE.

Both studies used the reliable online test framework of [13], which adheres to the best practices for crowdsourced QoE studies [14] including monitoring of test execution and automated consistency checks. Workers were recruited on the crowdsourcing platform microworkers.com. After the participants accessed the test framework, they had to read the task description, complete the display and audio pre-tests, and answer a short demographic questionnaire. The users were instructed to focus on the quality of the video sequences and did not receive any prior knowledge of the presence of the advertisement. In the meantime, the required clips were downloaded to the local browser cache to avoid network induced degradations during the video playback. When all video clips were in the local cache, the user proceeded to a web page, which contained only the video player on a gray background, to watch the first video clip. After the playback, the user had to answer questions related to that test condition, including the quality rating on a 5-point absolute category rating (ACR) scale. This process was repeated for all three clips, which were scheduled in randomized order. Finally, the user had to answer few more personal and consistency questions, including questions if he noticed any advertisement and the number of the advertisement clips played, before he received his payment code.

Due to the unsupervised nature of crowdsourced QoE studies, unreliable users had to be filtered out by checking the consistency of their participation in the subjective QoE study. First of all, the clicking behavior during the pre-tests indicated if users read and followed the instructions or not. Moreover, consistency questions and content questions were compared to the correct answers, and it was checked whether users watched all videos in their full lengths. If a user was considered unreliable based on these checks, his ratings were filtered out before the result evaluation. Additionally, ratings were excluded if technical problems with the test framework occurred, such as stalling of the video playback.

A. Advertisement Banners

The impact of advertisement banners on the web page of a video portal was investigated as part of the first video QoE study [5]. Three source sequences were used, namely, 10 s long clips from a rock concert, a basketball match, and a leopard documentary, which covered a wide variety of characteristics.

[1] http://www.videolan.org/developers/x264.html

A single advertisement banner was added to the plain video web page, which consisted of one or three ads, and was labeled "Advertisement" in the bottom right corner. A sample inspection of the test framework before the study ensured that the banners and ads were not removed by widely used ad blocking browser extensions. Each ad was either a static image or an animated gif showing oscillations between images and flickering. In total, five banner conditions were investigated, in which the banner contains of one static, one animated, three static, two static + one animated, or one static + two animated ads. Note that the banner condition was constant for all three videos, but the content of the ads was randomly chosen from a pool of ten static and ten animated images. In this campaign, 377 workers participated. The ratings of 161 reliable users could be evaluated.

B. Advertisement Clips

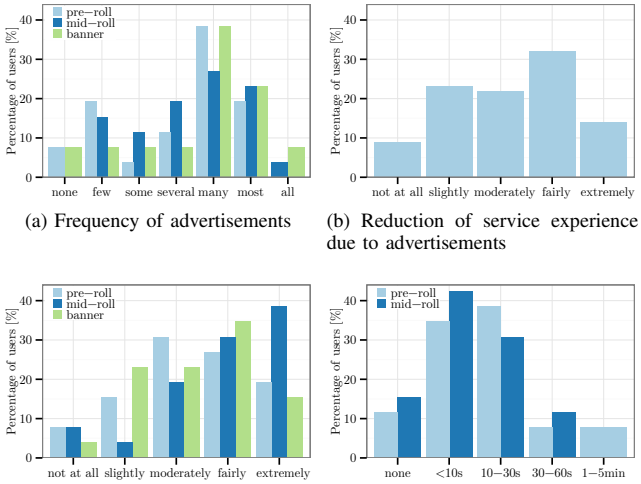
The second study investigated the impact of pre-roll and mid-roll advertisement clips on video QoE. Post-roll advertisement clips were omitted, as the start and first parts of online videos have a higher importance [6]. Three 30 s long content clips from a movie, a music show, and a cartoon were used, which included one scene change in the middle of the clip. The advertisement was either a 9 s (short) or 25 s (long) clip for tourism. These ad clips were always shown in the highest quality, either before the content clip (pre-roll), or during the content clip (mid-roll) at a fixed position, namely, the scene change of the content clip. During the playback of the advertisement clip, an overlay label was shown in the bottom left corner of the clip displaying "Advertisement" and a countdown of the ad duration. Note that advertisement clips could not be skipped but they had to be watched completely. The ad conditions were selected in addition to the quality level conditions, such that every user watched one sequence with the short ad clip, one with the long ad clip, and one without an ad clip in a randomized order. After rating all three clips, the participants were randomly assigned to answer theoretical questions either on advertisement banners, pre-roll clips, or mid-roll clips. These opinions were used to complement the research of both studies. 625 workers participated in this study, and the ratings and of 129 reliable users could be evaluated.

IV. Results

First, the opinions on advertisement banners and clips are presented, afterwards, the actual QoE ratings are evaluated.

A. User Opinions on Advertisements

The participants of the second study were asked theoretical questions about their perception and opinion of advertisements in video streaming services. These questions were asked after the rating of the test conditions to not focus the attention of the users on the advertisements that were presented implicitly with the video sequences. The participants were randomly assigned to answer theoretical questions either on advertisement banners, pre-roll, or mid-roll clips.



(a) Frequency of advertisements

(b) Reduction of service experience due to advertisements

(c) Annoyance due to advertisements

(d) Maximum acceptable advertisement clip length

Fig. 1: Theoretical opinions on ads in video streaming services

The first question asked for how many videos participants usually see an advertisement clip before/during the video that they have requested or an advertisement banner on the video streaming web page. Figure 1a shows the distributions of the answers for pre-roll (light blue), mid-roll (dark blue) clips and banners (green). It can be seen that less than 10% of the users never see advertisements in video services. Most users claim that they see advertisements for many videos, but not for all videos. Still, this shows that the presence of advertisements has to be considered when analyzing the QoE influence factors of video services.

Figure 1b shows the resulting reduction of the experience with a video streaming service by advertisements. The distribution shows that only 9% of the users do not consider ads to cause a degradation of the QoE. In contrast, 23% report a slight, 22% a moderate, and 32% a fair reduction of the service experience. For 14% of the users, advertisements are considered to degrade the QoE of the video service extremely.

When asked in detail if users are annoyed by advertisements, it can be seen in Figure 1c that many users consider ads as annoying. Thereby, mid-roll clips are by far worst as they are considered extremely annoying by 38% of the participants. This result comes as no surprise because mid-roll clips interrupt the consumption of the desired content video. Banners and pre-roll clips show quite similar distributions, in which the users consider them mostly only moderately or fairly annoying. Nevertheless, it can be seen that advertisements mainly provoke negative emotions. Only few users (4% for banners, 8% for clips) are not annoyed by advertisements.

The maximum acceptable length of advertisements is depicted in Figure 1d. Although some users do not accept any advertisement clips (12% for pre-roll, 15% for mid-roll), short clips might be accepted by most of the users. Generally, the distributions show that pre-roll clips can have a higher

length than mid-roll clips. The results confirm a study of 2000 consumers [15], in which 46% said the optimal length of a video ad is 1 to 15 s, and only 19% preferred an ad that is more than 30 s in length.

Considering that mid-roll clips interrupt the consumption of the desired content video, while pre-roll clips only increase the waiting time for the content, the results on annoyance (cf. Figure 1c) and maximum accepted length (cf. Figure 1d) of ad clips are in line with previous QoE results for stalling (interruption) and initial delay (waiting time), e.g., [3].

Furthermore, the users had the opportunity of leaving their own comment or opinion on advertisement, 159 users (25%) used this option. All these comments were further analyzed and categorized into several groups.

The largest group (approx. 40%) of comments can be labeled as *necessary evil*. These users understand the advertisement as a way how they can consume the content free of charge, however, they are able to accept the advertisement only when it is neither too frequent nor annoying. In this case, the users are willing to accept the advertisement as a pre-roll clip with a duration of maximum 15 s. A very frequent issue the users mentioned in their comments was also the loudness of the advertisement, for which they prefer the advertisement to be on the same audio level as the watched video content.

The next group of the users' opinion on advertisement clips can be described by the word *reject*. These comments have a share of approx. 15%, and users belonging to this group are not willing to accept advertisement clip at any circumstances. However, few users, who reject advertisements completely, are willing to pay a subscription of a service in order to have an advertisement-free experience. In 15% of the comments, the users stated that the advertisements should be either *related* to the video content or to their interests. Under these circumstances, users in this group are not only willing to accept the advertisements but are enjoying watching them. Finally, there was one thing common for all the groups of the users – *repetitiveness*. Users are highly annoyed by repetitive advertisement clips and are even willing to stop using such a video service.

To put it in a nutshell, the users' answers in the questionnaire and their opinions show that advertisements are perceived by users for most videos in video streaming services. While a few users totally reject any advertisements, and few users also enjoy watching them, most users have become accustomed to advertisements, especially if they are related to their interests or the actual video content. The users are annoyed by repetitive advertisements, and consider mid-roll clips more annoying than pre-roll clips and banners. Moreover, 91% report that advertisements also degrade the QoE of the video service. In the following, these subjective impressions are checked against the actual video QoE ratings of the users.

B. QoE Impact of Advertisements

Having these opinions in mind, in the following, the actual QoE ratings of the users are evaluated. First, the results of the study on advertisement banners are presented, and afterwards the results of the study on advertisement clips.

1) Advertisement Banners: Figure 2 shows the distributions of QoE ratings on a 5-point absolute category rating (ACR) scale ranging from bad (red) to excellent (green). The three rows represent different video qualities high (H), medium (M), and low (L), and the columns depict different video contents (basket, leopard, wacken). In all nine subplots, the bars represent the different advertisement-related test conditions, which are summarized in Table I. Each condition was rated on average by 17.50 reliable users. It can be seen that the QoE ratings are significantly influenced by the content quality, as lower video quality results in lower ratings on the ACR scale. This is confirmed by the analysis of variance (ANOVA) of the results, which gives a p-value of $2 \cdot 10^{-16}$.

When comparing the different advertisement-related test conditions, the 95% confidence intervals of the mean opinion scores (MOS) overlap. Also the ANOVA shows a p-value of 0.0546, which is not significant on the typical level of significance of 5%, and thus, confirms that there is no effect of the test condition. This means that there is no impact of the presence of advertisement banners on the video QoE. Furthermore, the results of the ANOVA showed that there is not any statistically significant impact of any joint condition.

Considering only the impact of the different banners, i.e., only the conditions in which the advertisement banner is present, gives a p-value of 0.672. Thus, the different compositions of the advertisement banner with static and animated ads also do not significantly impact the video QoE.

2) Advertisement Clips: Figure 3 shows the QoE ratings of the study on advertisement clips. Again, the rows depict different video qualities and columns represent different video contents. The ad clip test conditions are shown in Table II, each condition having been rated on average by 7.67 reliable users. The influence of the video quality is still obvious and can be confirmed by ANOVA giving a p-value of 10^{-16}. When evaluating the impact of the test conditions, i.e., the presence of different advertisement clips, there is no direct impact on the QoE visible (p-value 0.692). If the ad clip conditions are analyzed separately, there is not any significant impact again with p-values 0.550 and 0.342 for ad clip length and ad clip position, respectively. Also a joint influence of content and test conditions cannot be confirmed with a p-value of 0.0711.

Although the users did not have any prior knowledge of the presence of the advertisements clips, the influence of its presence on the overall QoE can be seen. In Figure 4, all test conditions with an ad clip (S/P, S/M, L/P, L/M) are combined into group "ad present" (dark blue), while condition "none" is represented as group "no ad present" (light blue). The plot shows a subplot for each content, and each plot depicts the MOS and 95% confidence intervals for the different quality levels and the two groups. It can be seen that the 95% confidence intervals still overlap, and the ad presence itself does not significantly influence the MOS (p-value 0.280). However, it can be seen that the "movie" content always scores a higher MOS in the presence of the advertisement clip. This

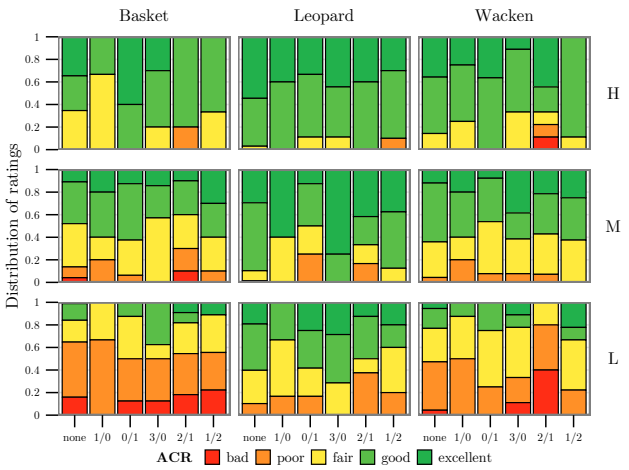


Fig. 2: QoE results for advertisement banner test conditions

TABLE I: Description of ad banner modes

MODE	DESCRIPTION
none	No advertisement
1/0	1 static ad
0/1	1 animated ad
3/0	3 static ads
2/1	2 static ads, 1 animated ad
1/2	1 static ad, 2 animated ads

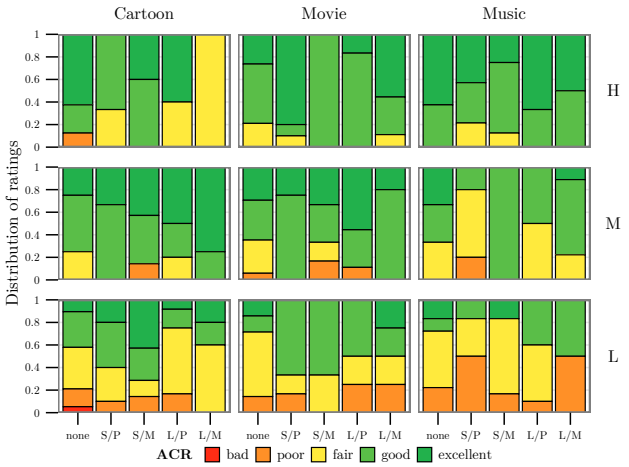


Fig. 3: QoE results for advertisement clip test conditions

TABLE II: Description of ad clip modes

MODE	DESCRIPTION
none	No advertisement
S/P	Short ad, pre-roll
S/M	Short ad, mid-roll
L/P	Long ad, pre-roll
L/M	Long ad, mid-roll

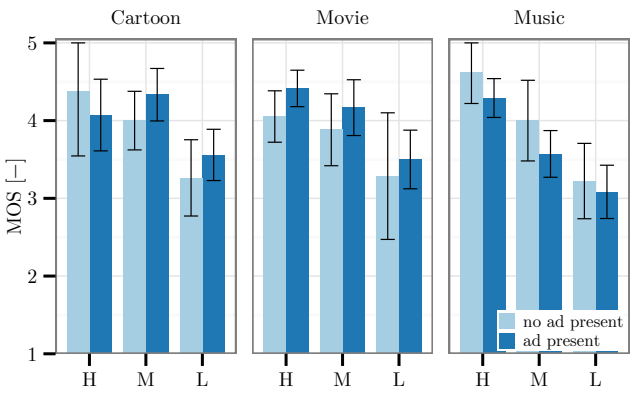


Fig. 4: MOS impact of presence of advertisement clip

suggests an impact of the joint condition of content and ad presence, which is confirmed by the ANOVA with p-value 0.025. Note that this peculiarity might be specific to this study.

To sum up, the analysis of the QoE ratings showed that the influence of advertisements on the QoE is not trivial. Both the presence and composition of advertisements banners did not show any significant impact on the users' ratings. This can be explained by the omnipresence of advertisement banners to which users have become accustomed. Also for advertisement clips, at first sight, no impact could be detected considering advertisement presence, position, or length. However, when analyzing the ratings in detail, an influence of the joint condition of the presence of advertisements and the content of the actual video was found. This resulted in a significantly higher MOS for one content, when ad clips were shown.

Nevertheless, all results together indicate that there is a complex interplay of advertisements and QoE. Generally, the negative opinions of users, who considered advertisements a QoE degradation could not be observed in immediate video QoE ratings. This suggests that the perception of video quality and the perception of advertisements are processed differently, and might orthogonally add up to form an overall QoE of the video service at a later point in time, e.g., a negative impression might form after using a video service over a longer period of time with frequent, repetitive advertisements.

V. CONCLUSION

As most video streaming portals monetize their service by displaying advertisement banners or showing advertisement clips with the actual video content, these advertisements can annoy or distract the user from the video content, which might result in a degraded service experience. To investigate this phenomena, two crowdsourcing studies were conducted. In both studies, users were given the task to rate the video QoE of test sequences with different, distinguishable quality levels. During this rating task, advertisement banners or clips were shown, which constituted the actual test conditions. Their impact on video QoE was evaluated, and compared to theoretical opinions of the participants on advertisements in video services.

Evaluating the theoretical questions, it was found that only 9% of the users do not consider ads to cause a degradation of the QoE, and short clips might be accepted by most of the users. While banners and pre-roll clips showed similar distributions regarding the annoyance, mid-roll clips were reported to be worst. These opinions are in line with previous results for the QoE of HAS that interruptions (stalling, mid-roll clips) are perceived worse than increased waiting times (initial delay, pre-roll clips).

When analyzing the users' comments about advertisement, many users considered ads a necessary evil. Some users appreciate advertisements when they are related to the video content or their interests. While repetitions of ads generally annoy users, only around 15% of the comments contained a clear reject of advertisements.

To investigate the actual QoE impact of displayed advertisement banners during the video playback, a single banner was added to the video web page. Depending on the test condition, the banner consisted of one or three ads, which included static images and animated ads with flickering images. While the QoE ratings were significantly influenced by the quality levels of the content, no effect of the presence of advertisement banners could be observed. Also different compositions of the banner with static and animated ads did not significantly impact the video QoE.

The second crowdsourcing study added advertisement clips to the content video. Again, the influence of the quality level of the content was significant. However, the different advertisement clips and their position did not have a direct impact on the QoE. These findings partly differ from results published in [9]. However, as our study employed a crowdsourcing-based evaluation, the participants might have found it natural to see advertisement during their session. Only the joint condition of content and advertisement presence had a significant impact on the QoE, such that one content could reach a significant higher MOS with ad clips than without. This suggests, that the content of both the advertisement clip and the actual video sequence might have an impact of the QoE as well. However, this is beyond the scope of this contribution already and a more detailed study incorporating different contents of the advertisement clips would be necessary.

The actual QoE ratings could not confirm the users' impression that advertisements are a QoE degradation. Instead, the results suggest that there is a complex interplay of advertisements and QoE. It seems that users can distinguish between the immediate video QoE, which was not affected by the presence of advertisements banners and clips, and the overall service QoE, which was reported to be degraded by advertisements. Additionally, the users' opinions indicated that waiting times due to pre-roll ad clips and service interruptions due to mid-roll ad clips might play a role – just like initial delay and stalling in previous QoE studies of HAS – although no impact was visible in the video QoE ratings. Thus, the overall QoE of a video streaming service might be composed from orthogonally perceived QoE factors (e.g., video QoE, waiting times, interruptions, advertisements), and might form later after using a video service frequently over a longer period of time.

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