Journal of Universal Computer Science, vol. 19, no. 12 (2013), 1736-1760
submitted: 12/10/12, accepted: 26/6/13, appeared: 28/6/13 © J.UCS

The Analysis of the Users' Response to the Linear Internet Video Advertising by Using QoE Methods

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Abstract: Internet video advertising is a sensitive application regarding the quality of the multimedia content, efficiency of displayed advertisement and user's attention. Therefore, video advertising have to be described with respect to Quality of Experience (QoE). Important issue represents trade-off between the Quality of Experience and ad efficiency. The analysis of payment which takes into account the duration of video ad is one of the aspects in this research. This paper analyzes influences of the format of the video ad to user's attention in order to achieve optimum ratio between the efficiency of the ad and QoE. We investigated impact of the position of the video ad in video content, ad duration and transition effects in merging video contents to the user's attention and ad efficiency. The model for estimation of QoE, taking into account improvement efficiency of video ad, was presented and metrics which are necessary for the evaluation of the QoE are introduced. The results show that it is possible to design video ad to achieve optimal ratio between the efficiency of ad and QoE. The improvement of the efficiency of an ad may be achieved while retaining the maximum QoE at the same time.

Keywords: Quality of Experience, Content adaptation, Internet video advertisement modelling, Subjective quality assessment, User's attention
Categories: H.3.5, H.5.1, H.5.2, M.6

1 Introduction

Contemporary Internet-based communication trends continually provide new opportunities for information placement, presentation and application. We are witnesses of the rapidly growing trend of video materials usage for various on-line business purposes, and on-line video advertising is one of them. Moreover, this form of advertising has become one of the fastest growing Internet-based business concepts.

In terms of quality, multimedia communications, including on-line video advertising, are very sensitive applications. It is therefore understandable that increasing the end-users' experience and perception about the quality of the multimedia content is one of the major trends in the multimedia communications. In

order to provide an adequate quality of the content that would satisfy an end-user, it is crucial that all participants in the multimedia content placement systems take a pro-active role in the improvement of all segments of the system.

The development of the Internet technologies improves the services and applications in terms increasing the user's activity. Through the interaction with the multimedia content, the users may find that the ads are more impressive [Hua et al., 08]. According to the research conducted in this field, the application of interactive video content results in a greater participation of users and in a stronger interaction between advertisers and users, than when static media (static image or banner) are used to convey the information browsed by the users [Rosenkrans, 09]. In addition, the findings indicate that interactive video advertisements have a greater impact on end-users regarding increasment of brand awareness than any other form of on-line advertising [Cole et al., 09].

Constant improvements of the video content quality and methodology of delivery is resulting in increasing the needs and requests of an end-user. The efficient placement of services requires adequate technical pre-requisites and this is most often described as the Quality of Service concept (QoS) [Seitz, 03]. On the other hand, the Quality of Experience (QoE) concept is used as a relevant measurement tool when the end-users' subjective perception of the service or application is evaluated [Moorthy et al., 11]. This entails the need for a continual QoE analysis that would guarantee the required level of service quality. The modern QoE environment can be analyzed by means of definition and realization of additional values by identifying and improving different factors which influence the increase of the QoE [Heger and Schlesinger, 10]. Earlier research mostly linked QoE with the technical aspect of the QoE improvement. However, QoE has recently been viewed as a complex problem which, apart from technical, includes many other aspects, thus adding more complexity to the QoE concept. Technical issues, business models and human behaviour covered by communications ecosystem can be analyzed using concept of the QoE [Kilkki, 08]. International Telecommunication Union (ITU) defined the basic parameters for the QoE evaluation [International Telecommunication Union, 08]. The QoE concept is also described by the degree of the end-users' satisfaction with the delivered service or application, which puts end-users in the focus of interest of all other participants in the realization and placement of services [Fiedler et al., 09]. Quality of Experience model can be used within different Internet Multimedia Applications, like e-learning [Scotton et al., 10], online advertising, IPTV (Internet Protocol television), etc.

It has become evident that the level of the end-users' experience and satisfaction with the provided content and service considerably determines the trends of service development and has an influence on the motivation of all participants in the system for a more efficient and effective delivery of multimedia content. For this reason, in the Internet-based video advertising system, all key participants in the realization of the service (content provider, service provider and advertiser), as well as the end-users, are interested in the improvement of the QoE.

The outline of paper is organized as follows. In Section 2, we present an Internet video advertising overview from the technical and financial aspect. In Section 3, we present previous approaches used in related work regarding Quality of Experience in multimedia applications. In Section 4, we explain our framework and define our

problem. In Section 5, the experimental results are presented and discussed. Finally, in Section 6, we gather the major conclusions and future work.

2 The Internet video advertising overview

The main purpose of Internet advertising is to generate traffic and increase revenue for all participants in advertising business. In order to achieve these two goals, visual form of information representation provides the best results, so multimedia advertising became the most important model of advertising.

2.1 Internet video ad delivery-technical background

Multimedia advertising model includes different entities which interact between themselves. General model of multimedia advertising architecture is represented in Figure 1, [Vratonjic et al., 10].

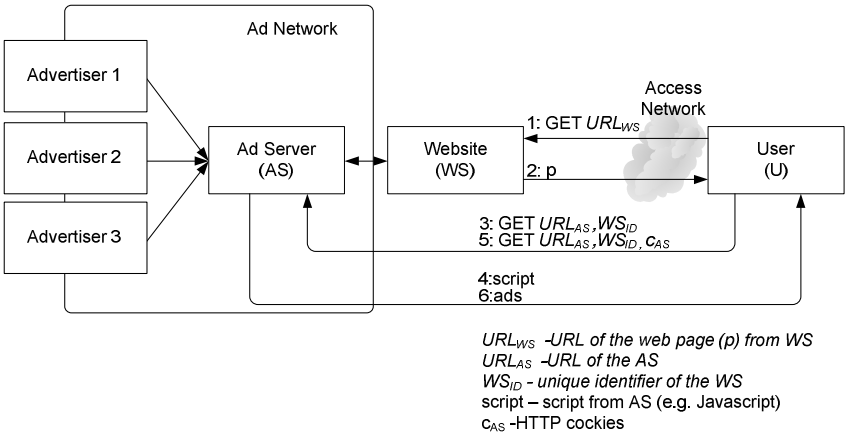


Figure 1: General model of multimedia advertising architecture

Advertisement (ad) may take different forms: banner, image, video or combination of different forms. In this paper video ads (video clips), are mainly discussed. The model presents that Advertisers are connected to an Ad Network (AN) entity which represents service provider between publisher and advertiser. Ad network is in charge of storing ads, optimization of ad selection and embedding the ads into web pages. The Ad network has agreement with the publishers who own the websites (WS) in order to place the ads to web pages.

In order to give Ad network and advertisers full control over the ads, the online advertising system uses HTTP protocol. The communication scheme between the entities, based on use of HTTP messages, is also illustrated in Figure 1. The message exchange includes several steps within the process of the delivery of the ad. Within the steps 1 and 2 user is visiting website (URL_{WS}) and he/she downloads interesting content of the web page (p). In step 3, he is redirected to one of the Ad server (AS)

using the URL of the AS (URL_{AS}) and unique identifier of the WS (WS_{ID}). After that, in step 4, script from AS is served and executed at user's device, which enables user to fetch ads from the server which is performed in step 5. The cookies (c_{AS}) are used to uniquely identify users and their browsing preferences. Finally, the ad is served to a user in step 6. The main advantages of this topology and methodology for ad serving are that the control over the storing and maintaining the ads is given to ad serving network and advertisers, whereas the advertisers can track users across multiple websites to serve the ad, and the HTML code is used to easily direct users to fetch ads [Vratonjic et al., 10]. The activities of an ad network directly affect the effectiveness of the multimedia advertising system. The service provider, with the role of intermediary commercial ad-network in advertising system, has two main goals: increasing the revenue for all participants in the advertising system and improving user experience.

In terms of methodologies, Internet advertising can be summarized as conventional advertising and contextual advertising. Main difference is the methodology of embedding the ads. Conventional advertising system, as first generation, uses text content to match relevant ads around the media content. On the other hand, second generation advertising system, so called, contextual advertising system selects ad relevant to media and embeds it within the media. General framework of multimedia advertising is shown at Figure 2.

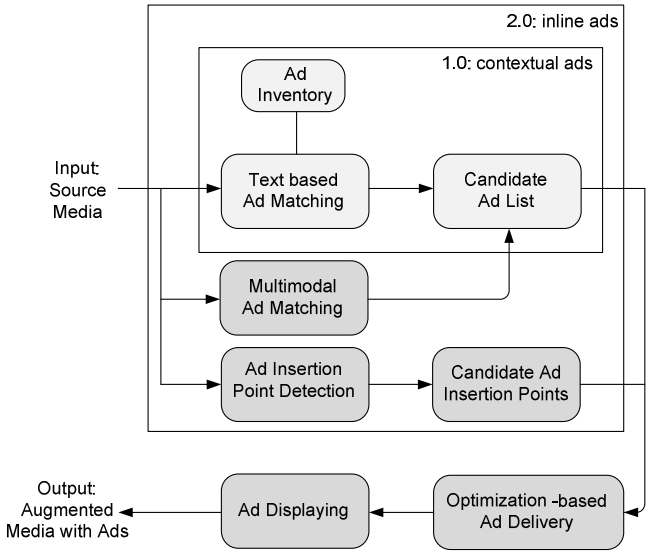


Figure 2: General framework of multimedia advertising [Mei and Hua, 10]

Both of them, using different carriers of advertising information, were successfully realized through specific advertising platforms. Google's Adwords [AdWords, 12], AdSense [AdSense, 12] and DoubleClick [DoubleClick, 12] embed the ads at the fixed positions by using text as carrier. Platforms which are using the media as carrier, especially in video domain, and embedded ads at the fixed positions

are, Youtube [YouTube, 12] and AdSense. Vibrant Media [Vibrant, 12] and MediaSense [Duan et al., 06], [Mei et al., 09] are contextual advertising platforms where the ads are embedded within the text and the media, respectively.

The multimedia advertising is using images and videos as carrier, so the main problem is how to embed the ad in order to achieve maximum ad relevance and user experience. Evolution of the advertising involves many complex problems (contextual relevance, contextual intrusiveness, insertion optimization and rich displaying) important to solve for efficient Internet advertising [Mei and Hua, 10]. Local visual relevance has been researched very often [Guo et al., 09], [Mei et al., 10], [Mei et al., 07], because similarity between ad content and video has strong influence on viewers attention. Another important question is where the ad content should be embedded and displayed based on the contextual intrusiveness [Mei et al., 09].

In the contextual advertising, the relevance of an ad can be derived from multimodal similarity (textual, visual, and aural), which is performed using perception similarity analysis and semantic concept. Detection of an ad insertion point is another task important for embedding the ad within the video content in order to maximize the overall relevance of an ad. Authors in [Mei et al., 07] presented the online video advertising system which inserts the ads at the most appropriate positions within the video. The authors addressed the important problems of serving video ads such as: position of the video ad within the video stream and contextual relevance of an ad to online video stream. They used global textual relevance to find the most relevant ads, and local visual-aural relevance to find good matching between each insertion point and ad. Two measurements for detecting ad insertion point are proposed: content discontinuity and attractiveness. Those measurements required user studies in a typical viewer audience.

2.2 Financial aspects of Internet video advertising

Internet-based video advertising is a complex process involving many participants where the mode of interaction among them determines the methods of collecting fees for services. As far as the costs of sustainable functioning are concerned, the participants pay among themselves for the services and resources that they use. For example, end-users pay fees to their ISP (Internet service provider) for the usage of Internet connection, ISP pays the network operator for the access to its network infrastructure, whereas service providers pay fees to network operators or CDN (Content delivery network) operators for advertising their content. CDN operators also have costs for using network infrastructure, payable to their network operators.

The method of selling advertising resources is a top priority in the on-line video advertising system. Currently, the most common method of payment is the one based on the manner and number of video advertisement displayed to the end-users. The advertising fee is determined by the type of advertisement and the advertising mode. Some of the fee calculations described below are often in use:

1. CPM (cost per mile) is the method where the fee for total number of advertisement displays, mostly banners, is determined in advance.
2. CPC (cost per click) is the method where the profit is generated solely from the number of advertisements that the end-users “clicked on”, and which have realized the connection to the some other page in the campaign.

3. CPE (cost per engagement) is the method of calculating fees where profit is generated if the end-user, when accessing an advertisement, simultaneously accesses the purchase of a service or goods, applies to a mailing-list, etc.
4. CPA (cost per action) is an advanced version of the CPC method. It engages the user in interaction with the displayed content what results in a continued advertising campaign (on-line games, surveys, etc.)

The choice of the video advertisement display mode and the method of payment directly depend on the impact of the advertisement on the page visitors. Moreover, the issue of evaluating the effectiveness of the displayed advertisement is a complex one and very difficult to determine. The common characteristic of the above-mentioned methods which are currently in use in on-line advertising is that, in fact a pricing scheme is based on the number of impressions delivered. In terms of advertising the impression is one download of an ad. The number of downloads is used to calculate the number of delivered impression for that ad. This concept of payment does not take into account how long an advertisement will be displayed, so advertisers pay for a number of impressions or better say number of downloads of an ad.

Recently, the researchers have pointed out the advantages of collecting advertising fees by using metrics which do not include number of impressions. The fees for displaying advertising content could be determined by the amount of time that visitors spend on viewing the advertisement. This could have two very important effects. First, more efficient method of payment would be introduced, measuring the time spent on viewing the advertisement. Second, the advertisers would be stimulated to buy advertising time [Goldstein et al., 11].

According to the similarities with the concept used by the radio and TV, it is important to analyze the effect of an Internet advertisement on the viewer in terms of the duration of display and the position of the advertisement relative to the key video. It is therefore necessary to analyze the duration of the advertisement display in order to calculate the fee and define adequate metrics.

The current trend of fee calculation based on the duration of on-line video advertisement opens new areas for researching the issue. The analysis of payment methods which take into account the duration of on-line video advertisement is one of the possible aspects of research. Another important task that should be looked into is the QoE of end-users from the perspective of advertisement modelling. It makes possible the choice of video advertisement format which brings about the best of QoE to its viewers.

3 Quality of Experience in multimedia applications-related work

The video streaming represents the fastest growing application which dominates the Internet traffic share. Because of that, QoE of video streaming improvement possibilities are intensively investigated. One of the key questions is how to efficiently assess QoE of video streaming services by the end user. This problem is increasing if the different services and business concepts are merged. Good example is an online video advertising, were the video advertising content is delivered to end users within the Internet video streaming services. In that case, the QoE influence factors should be addressed for video streaming and Internet Video Ads separately.

Based on that, in analyzing the appropriate QoE influence factors, we can speak about video QoE and Ad QoE.

In order to precisely identify features of the QoE and factors influencing QoE, it is necessary to distinct the terms "Quality" and "Experience". The activities of the European Network on Quality of Experience in Multimedia Systems and Services about the Quality of Experience (QoE) concepts are definitely very intensive and provides basis for further research. In the [Le Callet et.al., 12] authors defined "Experience" as an individual's stream of perception and interpretation of one or multiple events. The event represents an observable occurrence determined in space, time and character. On the other hand, "Quality" is defined as an outcome of an individual's comparison and judgment process, which includes perception, reflection about the perception, and the description of the outcome.

It is important to underline that these definitions have to be understood from an individual's point of view within the concept of QoE. Finaly, working definition of Quality of Experience is: "Quality of Experience (QoE) is the degree of delight or annoyance of the user of an application or service. It results from the fulfilment of his or her expectations with respect to the utility and / or enjoyment of the application or service in the light of the user's personality and current state" [Le Callet et.al., 12].

3.1 QoE influence factors

Considering the definition of QoE and presence of different influences to the QoE we find that users' response to the linear Internet video advertising is interesting topic for research. Complexity of the QoE for the user may be illustrated with dependency from influence caused by service, content, network, device, application, and context of use. Internet video advertising represents an application area where maximized QoE can significantly improve effectiveness of the service and increase revenue. In order to maximize QoE, the characteristics of a user, system, service, application and context of use should be analyzed in detail.

Factors that influencing Quality of Experience may be grouped into three categories: Human influence factor (IF), System influence factors (IF) and Context Influence factors (IF). Human IF depend on the characteristics of a human user, system IF represents factors related to technically produced quality of application or service and context IF are factors that describe users environment from different aspects [Le Callet et.al., 12].

Each of the categories of QoE influence factors can be divided in several sub-category. Depending on characteristics that these factors are influencing, this classification can be performed more precisely for each sub-category. The overall classification of QoE influence factors is illustrated in Figure 3.

Internet video advertising is a multidisciplinary application. Because of those many characteristics of a system, service, application or context of use may have influence on the Quality of Experience for the user. In this paper we summarized most important QoE influence factors for in-stream video advertising application.

In-stream video advertising assumes usage of two types of video content: regular video content that user is watching and inserted video ads. For that reason it is important to underline main differences between the QoE of video streaming and QoE of Internet video ads.

The QoE of video streaming is affected by different influences as:

- Video quality of the (non-ad) content. Perceived quality of video is often caused by visible distortions which may be introduced by codec. Some of distortions are: blockiness, blurring, color bleeding, false edges, jagged motion, chrominance mismatch, flickering, aliasing, etc.
- The significant perceptual factor in multimedia of QoE is synchronization between video and audio.
- Errors occurred during transmission. Important transmission of QoE influence factors are initial delays and interruptions, e.g. due to technical problems. The visual effect of lost information occurred by packet loss, delay and jitter as visual effect have strong influence on perceived quality.
- Important QoE influence factor is channel zapping time. The channel zapping as influence factor of QoE of IPTV describes how quickly users can change between channels.

In case of video advertising delivery some additional QoE influences can be addressed. Depending on video ad placing methodology, format of the video ad and displaying the video ad, QoE of Internet video Ads depend on:

- Ads before, during (in-video) or after the video may have different influence to user experience,
- Duration of ads,
- Insertion optimization. The best association between the advertisement and insertion point may increase user experience,
- Contextual Ad relevance. Selection of relevant advertisements may enhance user experience [Mei and Hua, 10],
- Contextual intrusiveness. Using appropriate ad insertion positions within video influences the user experience,
- Ads that usurp the control may have negative impact on user experience. [Rohrer and Boyd, 04]
- Deceptive ads may have negative influence on user experience,
- Additional time for loading the ads. The delay time in display ads should be reduced in order to serve the ads expeditiously and to increase QoE of video Ad [Li et al., 09].

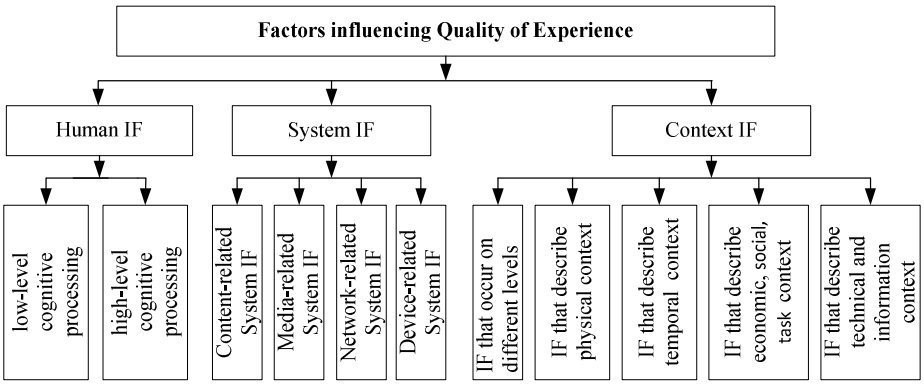


Figure 3: The main categories of QoE influence factors

3.2 Waiting times in Quality of Experience for Internet video advertising

Internet video advertising, as a common Internet application, is characterised by influences to the continuity of video consumption. The main reason is that consumption of the video is interrupted or delayed because of the inserted ads, so it is obvious that the main QoE influence factors are waiting times.

In this context, the waiting time may be understood as the time in which the ad is displayed. During the displaying the ad, the video is interrupted so this influence to the user's QoE should be investigated in detail. There are similar researches that deal with the waiting time as QoE influence factor.

The impact of waiting times and delays on QoE for web-based applications such as video streaming is deeply analyzed in the [Egger et al., 12]. Authors presented that there are considerable differences across different services (YouTube, 3G Internet connection setup and authentication in social networks) for the same initial waiting times. It may be caused by the different application context and resulting user expectations. Authors concluded that the influence of waiting times in the context of interactive applications is relevant topic which should be investigated interdisciplinary. This study we have used to support defining our research directions.

Internet video advertising represents a typical example were psychological, technical and financial aspects of this application can be analyzed together. The time perception adheres to some fundamental principles, but it is highly subjective and context dependent. Because of that its influence to QoE should be analyzed for application like Internet video advertising in detail.

In [Hossfeld et al., 12], the authors investigate the effect of those waiting times during a video (referred to as stalling, i.e. interruptions of the video for a certain time) and before a video (referred to as initial delay). An important contribution of this paper is defining the quantitative relations of QoE to the waiting times. This QoE research challenge is important for every application and service which is based on Internet video delivery. They found that QoE of a given waiting time strongly depends on the concrete application, but that the user rating diversity remains remarkably application-invariant.

Their research also showed that the initial delays are less harmful to QoE than stalling events for online video services. Authors stated that service interruptions have to be avoided in any case. They also investigated impact of delay and stalling for different video durations and found that stalling invokes a sudden, unexpected service interruption which significantly impacts QoE. Duration of delay impact is less because users are learning how much waiting time can be expected.

Based on those findings, we analyzed Internet video advertising service toward the QoE-optimal design of video ad. The main difference between our research and research presented in [Hossfeld et al., 12] is that we analyzed the QoE aspects in context of a concrete application (online video advertising) and waiting time in the consumption of the video caused by the inserting additional video content (video ad). There is an open question regarding the fundamental characteristic of interruption of consuming the video. The interruption when nothing is displayed and when the video ad was inserted and displayed to the user, have different effects to the QoE.

For support of this assumption important are results of the research [Robitza et al., 10] where the authors showed that displaying an ad in the zapping time is better than displaying nothing. The authors have shown that channel switching delays can

be treated in a similar way as delays in internet based services. Authors investigated impact of the gap type (Black screen, ”Please wait" animation, Static advertisement logo, Short commercial movie) and showed that a short commercial movie is the most acceptable intermission. They also confirmed importance of research regarding financial model in which the revenue is generated through placing advertisements within delivered media content, e.g in this case mobile TV. Authors also stated that there is need for defining maximum gap length that is still acceptable for most users.

In our paper we investigated how position of an ad within the video influences the QoE of the user, which is similar to the impact of the initial delay and stalling. Placing the different format of the video ad (pre-roll, mid-roll and post-roll) to the user, results in change of the user's attention. The different durations of the placed video ads may have impact to the level of user's QoE also. We found that results given in [Hossfeld et al., 12] and [Robitza et al., 10] are in line with our observations.

Temporal impairments of videos are important for QoE research in video streaming applications. The inserting of the video ads into video stream and interrupting the users attention is an important temporal aspect of the internet video advertising service. Service interruptions represent disturbance that affect users’ experience. The authors in [Minhas and Fiedler, 11],[Qi and Mingyuan, 06] investigated frame freezing and skipping at the beginning, in the middle and at the end of the video. They found that disturbances in the middle of the video are perceived worse than those in the beginning and at the end of the video. Within our research different methods of placing video ads in streaming video were analyzed, in order to investigate similar disturbance in video advertising. Our results regarding mid-roll video ad impact to user’s perception are in line with results presented in [Minhas and Fiedler, 11] and [Qi and Mingyuan, 06].

In order to o measure the impact of frame freezing impairments on perceived video quality, authors in [Huynh-Thu and Ghanbari, 09] presented a no-reference temporal quality metric which has high correlation with subjective data. Authors recommended to use presented metric in combination with other spatial quality parameters to produce a general video quality assessment. We find those results very useful for our future research regarding spatial impairments of video ads.

Modelling Quality of Experience (QoE) for online video streaming services is a important task because stalling events have influence on quality perception of service. Authors in [Hoßfeld et al., 11] conducted crowdsourcing campaign and found that for Youtube application QoE is primarily influenced by the frequency and duration of stalling events. Their result show that other factors like age, level of internet usage or content type have no significant impact to QoE. They show that crowdsourcing has high potential for QoE assessment of Internet applications so in future work we will use similar framework for analysis of user's response to linear Internet video advertising.

3.3 The aspects of QoE assessment in video delivery

The previous research has shown that the QoE is closely linked to the type of application and video content [Cerqueira et al., 11]. For this reason, the methodology of QoE management in the video content placement systems is important topic for researching.

It is obvious that the video quality has strong influence to the Quality of Experience. Therefore, it should differentiate an assessment of the video stream quality in terms of Quality of Experience (QoE) from the Quality of Experience based on the definition presented in [Le Callet et.al., 12].

In case of the video quality assessment for the service providers' purposes, specific tools and methods have been developed for the objective testing of the QoE which provide the Mean Opinion Score (MOS) calculation with a satisfactory precision. The comparison of results obtained by the use of subjective and objective methods of the QoE evaluation serves as the basis for the selection of the QoE modelling methodologies [Leister et al., 11], [Seshadrinathan et al., 10], [Seshadrinathan et al., 10b], [Winkler, 09]. The authors in [Agboma and Liotta, 11] have proposed a methodology that maximizes the QoE within closed network environment. The QoE is used to predict the quality of videos deemed acceptable by the viewers. The often analyzed QoE metrics deal with the assessment of the network environment and video coding impact on the viewers' experience. However, the metrics which take into account personal needs of viewers, characteristics of users' devices and the context of video content should be analyzed also.

Apart from attention aimed to the video quality and performances of the network environment, service providers must be aware of personal users' experiences, acceptance and expectations regarding the delivered service [Serral-Gracia et al., 10].

For this reason, the QoE modelling should be studied in detail, which makes it possible for the service provider to evaluate and improve the quality of the business service and application. The effects of the service to the viewer and the needs for QoE modelling are researched intensively. In [Hosfeld et al., 11] authors introduced the memory effect as a key influence factor for Web QoE modelling and proposed three different models describing the use: support vector machines, iterative exponential regressions, and two-dimensional hidden Markov models.

The evaluation of the user experience is important problem in multimedia advertising also. Different approaches exist in research community and the subjective evaluation tests are often used. Authors in [Rohrer at al., 04] described the importance of a user experience research role in understanding the nature and negative impacts of online advertising on user experience. They presented value of user experience analysis in decision making process for ad formats, ad characteristics, and where ads are best placed within the Yahoo! network.

The interruption of viewing the content is among the key factors affecting the quality of experience. The IPTV application is a typical example. There is a strong corellation between QoE and the channel zapping time. Channel zapping time is the time between the moment when the user presses the channel change button and the moment when desired channel was displayed on the screen. The viewing disruption in IPTV was analyzed by examining the effects of channel zapping time to the quality of the viewer's perception [Kuipers et al., 10]. Previous research has shown that the users' QoE can be improved in IPTV systems by inserting commercials during zapping time [Godana et al., 09], [Kooij et al., 09].

An In-stream advertisement, as well as advertisement shown during zapping time, influences the viewer by disrupting continuity of consuming the main video. Some of the main goals of advertising are getting attention, prompting immediate action, increase of sales or building brand awareness. The video advertisements should draw

the viewers' attention away from the main video being watched, but the user's QoE should not be significantly decreased. Because of that, QoE modelling is an important for in-stream video advertising. If adequate modelling provided the best user's QoE, the revenue generated from advertising will increase.

Based on previous research findings and Interactive Advertising Bureau recommendations [IAB Digital Video Committee, 09], we are analyzing, in this paper, the users' QoE in linear Internet video advertising. The formats of linear video ads and effects of an ad insertion in the source video, in order to improve the effectiveness of Internet video advertising system are analyzed using QoE methods.

4 QoE linear Internet video advertisement modelling

The principle of displaying video advertisements while the user is browsing certain content is a very important aspect in terms of doing business over Internet. It is applied in the multimedia systems such as IPTV, analogue television, Internet video, etc. In IPTV, a better QoE (according to viewers) is realized by inserting advertising material in the zapping time. On the other hand, in Internet video advertising it is necessary to establish the best way of video advertisement placement by determining the optimal ratio among the viewer's satisfaction, the effect of video content and the fee charged for video advertising.

In its guidelines, the Interactive Advertising Bureau defined the format of digital video in-stream advertisements [IAB Digital Video Committee, 09]. With regard to linear video advertisements, it described the possibilities of displaying video advertisements before (pre roll), during (mid roll) or after (post roll) the main video. Apart from these recommendations, IAB also set the guidelines for technical characteristics of video advertisements. These include resolution, types of codec, the number of frames per second, colour depth, etc. The recommended maximum duration of a video advertisement is 30 seconds. As the guidelines refer to a number of characteristics which may have different parameters, they should be analyzed along with modelling of the Internet video advertisement format in order to get the best possible QoE. According to the research findings, "pre-roll" and "mid-roll" advertisement displays are most commonly used in Internet video advertising, while the use of "mid-roll" method is on the increase owing to the current trend of showing varied content [Thurman and Lupton, 08].

In [Dorai-Raj and Zigmond, 10], the Initial Audience Retained (IAR) metrics is used to measure the reactions of the viewers to advertisements. IAR represents the ratio between the number of viewers who watched the whole advertisement and a total number of viewers. The reactions to pre-roll, mid-roll and post-roll methods of video advertising were analyzed, as well the duration of advertisements. According to the results, the viewers were most satisfied with the pre-roll advertisements. The viewers prefer 15-second advertisements to those lasting 30 seconds. Mid-roll video advertisements inserted in the primary video content are increasingly being used. Previous researches introduce the different approaches for inserting video advertisements. One possible approach is to insert the advertisements in the moments when the content of the primary video is not very interesting [Mei et al., 07] or when the context of the viewed video content is changing [Saito and Murayama, 10].

As mentioned before, the quality of user's experience of the content in Internet video advertising directly affects the viability and effectiveness of the service. For this reason, the measurement of the quality of experience is crucial in the process of Internet video advertisement modelling.

The interaction between the users and Web content was analyzed in previous research of the QoE modelling. The metrics for defining the traffic and network performances for QoE modelling, when the users search the content on the Web, were also suggested [Nguyen et al., 10].

In this paper the metrics which are closely related to the QoE of user are introduced. When viewing the displayed content, two key aspects of QoE modelling in the Internet video advertising can be identified. The first refers to the effects of the displayed video advertisement format, and the second to its technical characteristics. These two aspects can be applied to define appropriate metrics that are used to describe the above-mentioned effects. The metrics necessary for the evaluation of the QoE of the displayed video advertisement can be defined by using different video formats and characteristics recommended by IAB.

The implementation of different formats and technical characteristics of linear video advertisements to model improve the effect of displayed content on viewers are based on the metrics shown in Table 1.

Metrics determined by video ad format	
Video ad format	***Metrics***
Pre-roll	X_1
Mid-roll	X_2
Post-roll	X_3
Video ad duration	X_4
Metrics determined by technical characteristics	
Video characteristic	***Metrics***
Transition between video segments	Y_1
Resolution	Y_2
Number of frames per second (frame rate)	Y_3
Type of codec	Y_4
Color depth	Y_5
Aspect ratio	Y_6

Table 1: Metrics determined by the Internet video advertisement format and technical characteristics

The metrics X_k, where k= (1, 2, 3, 4), and Y_l, where l= (1, 2, 3, 4, 5, 6) are calculated on the basis of the used video format and its characteristics, respectively. The effects of both the format and the characteristics on viewers' QoE are defined as functions of individually determined metrics, as follows:

$X= f(X_1, X_2, X_3, X_4)$ and $Y=g(Y_1, Y_2, Y_3, Y_4, Y_5, Y_6)$.

For establishment of all necessary metrics for QoE estimation model, two independent metrics (X and Y) and metric which represents the correlation between these two metrics, are used. Consequently, XY metrics is defined as the correlation between independent metrics X and metrics Y.

In this paper we recommend the QoE estimation model for achieving more efficient and effective video advertisement placement. The model is based on the implementation of previously defined metrics and makes possible the defining of the advertisement format that will have the best effect on users.

A general model for QoE estimation, based on the analysis of the effects of video ad format and video characteristics, is presented in Figure 4.

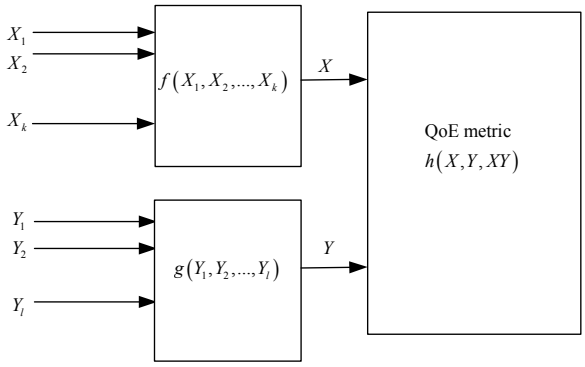


Figure 4: General model for QoE estimation, based on the analysis of the effects of video ad format and video characteristics

The model presents two groups of effects on the users' QoE, and the effect resulting from their correlation. Commercial and technical effects are described by X and Y metrics, while the effect resulting from their correlation is expressed by XY metrics. It is obvious that the conditions for obtaining the best video advertisement QoE can be defined by analyzing the choice of format, video characteristics and the results obtained after their correlation. In this paper, only the impact of Y_1 metric is considered. Impact of other Y_i metrics (Y_2, Y_3, Y_4, Y_5 and Y_6) was not considered in this investigation, please see Figure 5.

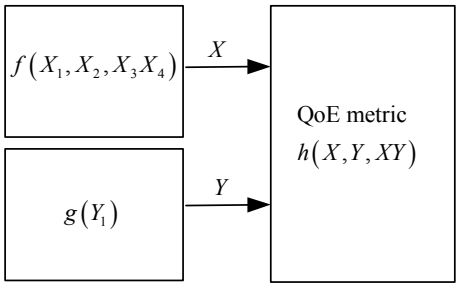


Figure 5: QoE assessment model based on advertisement format and transition model

5 Subjective assessments of linear in-stream video advertisement effects

5.1 Test methodology

The only relevant and reliable method for the assessment of the quality and effect of video content on viewers is by administering tests to viewers in which they have to state explicitly their perception of the video advertisement. This method is also known as the Subjective Video Quality Assessment (VQA).

The subjective video quality assessment has been standardized in ITU-T Recommendations. The Absolute Category Rating (ACR) method, defined in ITU-T Rec. P.910, is used in this study. In ACR method, test sequences are presented individually and rated independently of each other, according to adopted rating scale appropriate for this category of testing. The characteristic of this method is that viewers rate a test sequence immediately after viewing. Rating time is 10 seconds, while the duration of test sequence viewing varies and depends on test material content. The methodology of sequence presentation and rating, with clearly defined stages, is described using stimulus presentation scheme. The scheme used in this study is presented in Figure 6.

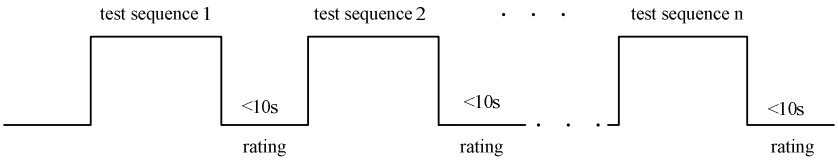


Figure 6: Test sequence presentation and rating graph

The scale for rating quality which the respondents use during the test is an important element of the testing process. Adequate rating scale helps keeping the character of testing on track as well as the consistency of the respondents' answers. The quality rating scale used in ACR testing usually has five levels, although an expanded scale can be used, if needed.

This paper applies the MOS scale which rates the level of viewer's attention directed at the primary video, or the level of the viewer's satisfaction with the primary video. In order to analyze only the video ad format and eliminate the effect of the video ad content, users rate the level of attention directed at the primary video, that is, the level of satisfaction with the primary video. The effect of displayed advertisement is thus indirectly assessed, and the effect is considered greater if the assessed level of the viewers' attention at the primary video is lower. The quality rating scale used in this paper is shown in Table 2.

In order to analyze only the effect of video ad format and eliminate other effects that are not in the focus of this research, we created specific video test sequences and used the presented MOS quality rating scale.

The experiment included the assessment of the following effects on the QoE:

a) Assessment of the effect of linear in-stream video ad, or the position of video ad in a video test sequence.

b) Assessment of the effect of video ad duration.
c) Assessment of the effect of transition mode between the video ad and the primary video.

MOS	**Impairment-gradation**
5 - Excellent	5 – Imperceptible The ad does not draw the attention away from the primary video.
4 - Good	4 – Perceptible but not annoying I notice the ad but it does not interrupt my viewing of the primary video.
3 - Fair	3 –Slightly annoying The ad distracts me from watching the primary video.
2 - Poor	2 – Annoying The ad distracts me considerably from watching the primary video.
1 - Bad	1 –Very annoying The ad totally distracts me from watching the primary video.

Table 2: Scale for quality rating and gradation

In accordance with the research objectives, the level of attention focused on the primary video was assessed, taking into consideration the above-mentioned effects.

The used formats and video ad durations were recommended by IAB, and the advertisement format and transition mode were described by metrics displayed in Table 1. The model which illustrates the assessment of QoE based on advertisement format and transition mode influence, while taking into consideration previously defined effects, is shown in Figure 5.

Depending on the level of attention focused on watching the primary video, and under the circumstances when linear in-stream advertisements of different formats and characteristics are being inserted, the effectiveness of advertisement and the users' QoE are assessed indirectly.

We tested two types of transitions to analyze the effects used in creating video content: a jumpy transition between video segments and transition which makes use of transitional effects of content merging. The effects of other technical characteristics (represented by metrics Y_2, Y_3, Y_4, Y_5 and Y_6) were not examined in this paper.

5.2 Test sequences

The experimental part of this paper evaluated the effect of video ad format and video segment transition on the viewer's attention by using test videos specifically created for this purpose. Test video consists of two segments: video advertisement and the primary video.

Given the fact that video ad content, primary video content and the context of the content where video ad is inserted all influence the subjective assessment, test material was developed in such a manner as to eliminate these effects. When creating test sequences, and in order to achieve consistency in the attention level rating by

taking into account only the effects of the positioning and duration of advertisements, the following elements were applied:

- The same advertisement content was used to create video ads of different duration in all test sequences. Video ads lasting 7, 15 and 30 seconds were created.
- The same primary video was used in all test sequences. Duration of the primary video was 3 minutes.
- The positions in video were the ad is inserted was chosen in a way to avoid two opposite effects: low or very strong influence. For example, in sports content we avoid exciting scenes. We chose the scenes when we expect that participant is relaxed during viewing the primary video.
- Three test data sets, based on different primary videos for each data set were created. Video material used as primary video for every each of data sets belongs to one of context classes: technology, sports and business.

In order to avoid the effects to viewer attention caused by the change of context in the primary video content at the moment of inserting video ad, the mid-roll and post-roll video ads were inserted always at the same time points in the primary video. The methodology of test video sequences formation is described in Figure 7. Figure also shows the manner of creating test sequences based on pre-roll, mid–roll and post roll video ad concepts as well as the use of transitional effects.

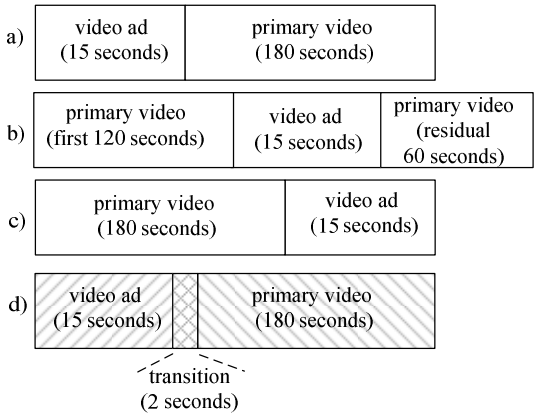


Figure 7: Test video example. a) pre-roll, b) mid-roll, c) post-roll test video, d) pre-roll test video with transition lasting 2 seconds

Video material of 640x480 pixels resolution and with display rate of 25 frames per second was used in the development of test videos. Pre-roll, mid-roll and post-roll video ads were created for each video ad duration (7 seconds, 15 seconds, 30 seconds) and using the same primary video. Jumpy transition (without transition effect) between the ads and video content was applied for nine test videos.

Additional nine videos were also created in this manner, but the effect of transition between the advertisement and the primary video was used. An effect that was applied produces two-second overlap between the advertisement and the primary

video and provides a smooth transition from one content to another. The transition between video segments is illustrated in Figure 7 d).

To sum up, 54 different test video sequences, 18 for each of three test data sets, were designed. These 54 videos represent a starting point for examining the effect of format and transition on the users' response to the video advertisement

5.3 The experiment environment setup

The level of user attention and efficiency of ad placement was assessed using previously described methodology.

The experiment was conducted in the computer lab located at the campus and equipped with 30 identical computers. The participants were divided in two groups, and participants of each group had conducted the test simultaneously. This approach enables assessment in identical environmental setup for all participants regarding the viewing distance, room ambient, light conditions and computer equipment.

The participants in this test were under graduated students, graduate students and administrative staff at the faculty. Considering that participants represent the average users who only consume video streaming content with the inserted video ads, they can be treated as non-experts. Before testing participants filled questionnaires with their personal data, background and technical experience. At the beginning of experiment, all participants were instructed about the test material, the method of assessment and the ITU MOS scale used in testing. The participants were then instructed how to rate the test video by using MOS scale after watching the video.

Unreliable users were identified and filtered out using task design methods found in [Hoßfeld et al., 11]. In this test is quite difficult to define the questions whereof the correct results are already known because the participants assess impact of inserted video ad. Because of that, we used content questions to identify reliable participant. The users were asked to answer a simple question about the inserted video ad and only users that gave the correct answers were considered in analysis. The example of question is: "What is advertising in inserted video ad? A) IT equipment. B) Food. C) Sport event". The consistency test was performed using several test sequences multiple times during the testing also. The participant's answers for same sequences were analyzed and if they slightly differ we considered them in analysis.

In total, 56 participants were involved in testing out of which three were excluded as unreliable. In the end, the answers of 53 respondents (25 male, 28 female) aged between 19-58 years (mean 31.8, median 29) were analyzed.

5.4 Subjective data processing and results

The assessment of ad efficiency and the level of participants' attention were based on the MOS scale presented in Table 2. The results obtained by the subjective evaluation of the level of attention while watching the primary video, depending on the format of linear in-stream video ads and the transition between video segments, were then processed and presented in Table 3.

MOS values calculated for the test materials were obtained by using the advertisements of different formats and duration, as well as by the sudden transition between the advertisements and primary videos. For the test video using the effect of

transition between the advertisement and the primary video, MOS values were expressed as MOS_t (MOS for test video with transition effect).

The effect of video ad is rated higher if the level of viewer's attention to content of primary video is lower. The effect of a displayed video ad is assessed as unacceptable if the MOS value describing the viewer's attention to the primary video is above 3,5. This means that the displayed video ad does not draw the viewer's attention strongly enough. In order to address respondent's difficulty or ease to rate attention level and the level of agreement among the respondents we calculate standard deviation as the square root of variance. If the variance is lower the agreement among the users is higher and it was easy for them to rate attention level. The 95% confidence interval is presented also in the Table 3.

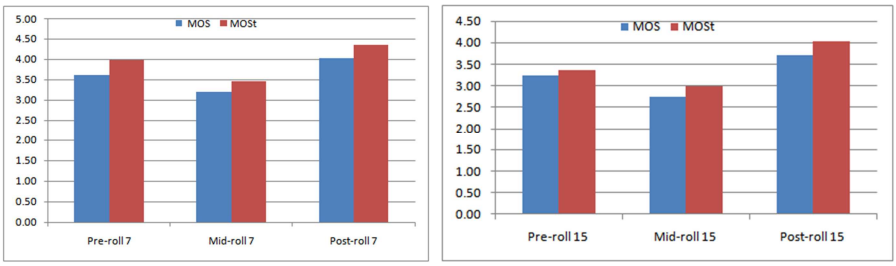
Type of ad	**With suden transition**				**With transition effect**			
	MOS	**Std.d**	**CI_{low}**	**CI_{up}**	**MOS**	**Std.d**	**CI_{low}**	**CI_{up}**
Duration of advertisement: 7 seconds								
Pre-roll 7	3.6	0.99	3.33	3.88	3.98	0.97	3.71	4.25
Mid-roll 7	3.21	0.79	2.99	3.42	3.45	0.8	3.23	3.67
Post-roll 7	4.04	0.92	3.78	4.29	4.36	0.9	4.11	4.61
Duration of advertisement: 15 seconds								
Pre-roll 15	3.25	0.9	3	3.49	3.36	0.92	3.11	3.61
Mid-roll 15	2.74	0.79	2.52	2.95	2.98	0.8	2.77	3.2
Post-roll 15	3.72	0.86	3.48	3.95	4.04	0.81	3.82	3.95
Duration of advertisement: 30 seconds								
Pre-roll 30	3.11	0.75	2.91	3.32	3.3	0.82	3.08	3.52
Mid-roll 30	2.42	0.57	2.26	2.57	2.68	0.64	2.51	2.85
Post-roll 30	3.66	0.76	3.46	3.86	4.02	0.75	3.82	4.22

Table 3: MOS for test video with different ad formats and the effect of transition

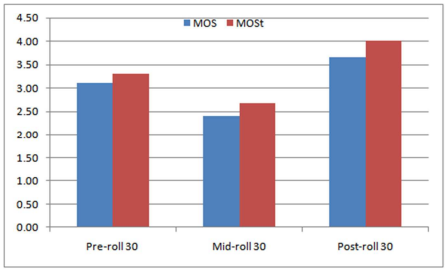
The results show that mid-roll video ads interfere with the viewer's attention more than pre-roll and post-roll for every of tested ad duration. In terms of inserted video ad duration, the results show that short ads (7 seconds) have the poorest effect on viewers, while the effect of 15-seconds and 30-seconds ads is much bigger than with short video ads. The analysis of the transition effect between the inserted video ad and the primary video has shown that for all video ad formats and all different ad duration the applied effect results in a worse perception of video ads.

From the analysis, we can see that in case of the mid-roll video ad, variance is lowest among the other video ad formats for the same ad duration. In this case user's attention to primary video is lower so video ad had bigger influence to the user also. Therefore, we can state that excellent subjective rating regarding the video add efficiency corresponds to a lower variance. The variance is lower for longer video ad what indicates higher agreement among participants during assessment

For the purpose of better illustration, the results from the Table 3 are graphically presented in Figure 8.



a) *b)*



c)

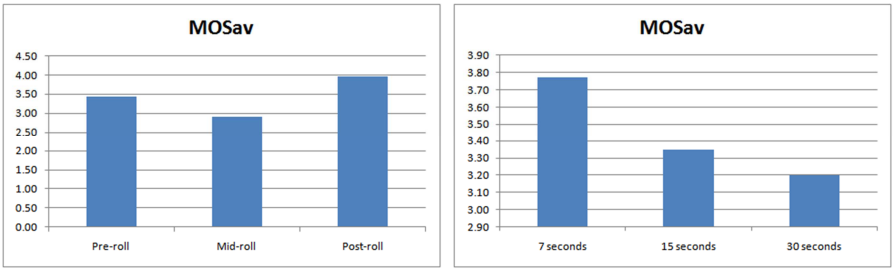
Figure 8: MOS values for: a) 7-seconds video ads b) 15-seconds video ads c) 30-seconds video ads

MOS (MOS_{av}) average values were also calculated for all sequences containing the same type of advertisement, regardless of the duration or whether the transition effect was used or not. Moreover, and in order to determine only the effect of video ad duration, MOS average values were calculated for all tested video materials containing the same duration of video ads, regardless of the type of advertisement or whether transition effect was used. MOS_{av} results are shown in Table 4.

Type of advertisement	**MOS_{av}**
Pre-roll	3,43
Mid-roll	2,91
Post-roll	3,97
Duration	**MOS_{av}**
7 seconds	3,77
15 seconds	3,35
30 seconds	3,20

Table 4: MOS average values for different formats and duration of video ads

The results presented in Table 4 are graphically illustrated in Figure 9.



a) *b)*

Figure 9: MOS mean values a) for different video ad formats b) for different duration

In this paper we also analyze demographics factors, gender and age, to user's attention and ad efficiency using ANOVA (Analysis of Variance) hypothesis-testing technique. We investigated is there significant impact of gender and age on linear video advertising efficiency.

We find that neither gender nor age represent statistically significant factor that contributes to the level of viewer's attention to the primary video and efficiency of inserted video ad. Our results are in line with previous research findings regarding effectiveness of online advertisements were authors presented similar findings [Mohamed and Alkubise, 12]. They explained this with the fact that there is no much genders difference using the internet. They also showed that Internet skills and usage per day affect user acceptance for online advertisement.

There is only one statistically significant factor regarding age. Participants aged from 20 to 30 years rated that pre-roll video ad lasting 30 seconds with transition effect influences to their attention. It can be understand that those participants are not satisfied with large waiting time before service consumption.

6 Conclusions and future work

Recently there has been a growing need for the Internet video ads effectiveness to be determined. In addition, instead of the prevailing concept based on number of delivered video ads, new opportunities are arising for quantification and charging fees for video ads on the basis of video advertisement duration. The above-mentioned objectives are in line with the trend of quantitative and qualitative assessment of service which is based on the QoE methods. This particularly may be applied to Internet video advertising. In order to achieve valid and universally applicable results, QoE assessments have to take into account IAB guidelines and recommendations that refer to video advertisement format and characteristics.

In this paper we analyzed the effect of video ad format and the effect of transition between video segments from the perspective of the video advertisement effectiveness. The analysis of the results obtained by subjective quality assessment methods showed that the efficiency of linear in-stream ads should be investigated

considering different QoE influence factors. This paper presents the model for QoE estimation considering more efficient and effective video advertisement design. The metrics which are necessary for the evaluation of the influence to QoE by displayed video advertisement are also presented in this paper.

According to research findings, the best influence on viewer's attention is achieved by displaying mid-roll video advertisements. The results from previous research were confirmed, demonstrating that pre-roll advertisements affect viewers' attention considerably, whereas the impact of post-roll video advertisements is much smaller. Research confirmed that the placement of longer video ads had more influence to user's attention than placement of shorter ones. It was determined that the effects of video ads lasting 30 seconds are bigger than effect of shorter ads, especially than ads lasting 7 seconds. The results indicate that users' attention is more easily attract if there is a sudden transition from the primary video content to the video ad content, than when transition effects are used in merging contents.

In conclusion, from the perspective of achieving the best possible QoE, mid-roll video ads lasting 30 seconds without implementation of transition effect between video ad content and primary video have the biggest influence to user's attention. The format and duration of video ad have significant influence to user's attention. Hence it is important to design optimally delivered video ad.

Statistical analysis of the subjective assessment showed, that gender has no significant impact on the user's perception of ad. There is no genders difference in using the internet, so this result is in line with previous research regarding efficiency of online advertisements. In case of analysis of age factor, we find that only for participants aged from 20 to 30 years, is present significant influence by pre-roll ads with transition effect. It means that these participants probably will not tolerate large waiting time before service consumption.

According to the findings, there is a need for Internet video advertisement modelling in terms of trade-off between QoE and effect of the ad. It is possible to design video ad to achieve optimal ratio between the video efficiency of ad and QoE. The improvement of the efficiency of ad may be achieved while retaining the maximum QoE at the same time.

The results also show that there are grounds for exploring models of payment for Internet video advertising which is based on the duration of video ads. The method of fee payment that depends on time spent on viewing the advertisement should be analyzed in detail, and advertisers should be stimulated to buy advertising time.

In the future research we will examine the effects of other video characteristics (codec, resolution, frame rate, etc.) on linear in-stream video advertisements efficiency.

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